Announced by all the trumpets of the sky,
Arrives the snow, and, driving o'er the fields.
Seems nowhere to alight; the whited air
Hides hills and woods, the river, and the heaven,
And veils the farmhouse at the gardens' end.

—R. W. EMERSON, from "The Snow Storm."

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FAVORING ABILITY GROUPING

NORMA SLEIGHT
New Trier Township High School, Winnetka, Illinois

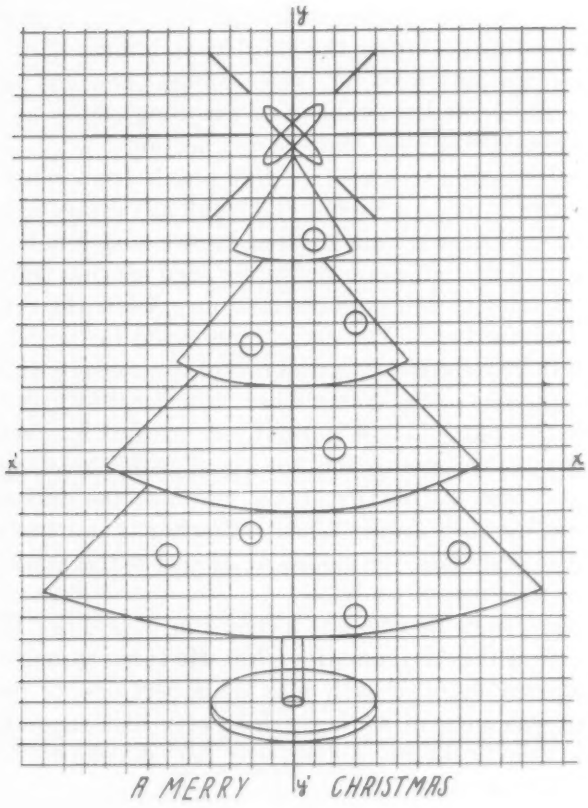
Ability grouping is practiced in New Trier Township High School. There are five levels of mathematics the first year, four the second, and three the third. During the third year intermediate algebra is taught, the main outline of the three courses being the same. However, let us glance at the problem of graphing conics and note one difference between the slow and the fast sections.

It is a real struggle to keep the slow pupils from plotting imaginaries and also to induce them to take full advantage of the double sign. They do not have a well developed sense of symmetry and form, therefore, errors are not noticed. Pupils need specific training in the matter of selection of values to use for x or y, while the keen students select wisely intuitively. The extra time saved in the better classes can be used to introduce standard forms of the conics with axes translated. A few graphs of the conics where rotation has taken place is a very instructive pastime and is usually demanded by circumstances. While mastery of this material is not a goal at this level, appreciation does produce some satisfaction in the minds of the curious and lays a foundation for the future. When a teacher is not burdened with slow pupils in the class, development of real mathematical sense in the gifted is much more probable.

A year ago James Brooks was a senior in New Trier High School and president of the Mathematics Club. He came through the mathematics program, enrolled each year in the sections for those of high ability. Jim was an avid worker, tried every idea suggested to him, and by the middle of his senior year had developed considerable mathematical power.

Jim had been on the "receiving end" of picture graphs two or three times but decided that he would like to produce one himself to be presented to the Mathematics Club for its Christmas program. He had very little difficulty except with a five pointed star at the top of the Christmas tree. He inquired about this. The only help he had was the suggestion that, while a four pointed star might not be quite so traditional, it would be much more practical. He knew that if $B^2-4AC<0$ in $Ax^2+Bxy+Cy^2+Dx+Ey+F=0$, the result is an ellipse. Having had some training in translation of axes during his intermediate algebra but knowing nothing about rotation except that the xy-term in the second degree equation produced a conic whose axes were no longer parallel to the coordinate axes, he proceeded. He made a study of the effect upon the shape of the ellipse produced by the variation of A, B, and C with respect to each other.

Following are the results of Jim's labors. He presents them to the readers of SCHOOL SCIENCE AND MATHEMATICS with his wishes for a Merry Christmas. The material is unedited.



"Place rectangular axes in the center of a sheet of graph paper. Plot the following on these axes. When you have finished, let me wish you a Merry Christmas!

1. $\left(\frac{x}{8}\right)^2 = y+8,\ y<-5.75$
2. $\left(\frac{x}{6}\right)^2 = y+2,\ y<.2$
3. $\left(\frac{x}{5}\right)^2 = y-4,\ y<5.2$
4. $\left(\frac{x}{4}\right)^2 = y-10,\ y<10.5$
5. Join (12, −5.75) and (7, −.6)
   Join (−12, −5.75) and (−7, −.6)
6. Join (8.9, .2) and (4.4, 4.8)
   Join (−8.9, .2) and (−4.4, 4.8)
7. Join (5.5, 5.2) and (1.4, 10.1)
   Join (−5.5, 5.2) and (−1.4, 10.1)
8. $8x^2+15xy+8y^2-240x-256y+2046=0$
   Hint: This equation is the same as
   $8x^2+15x(y-16)+8(y-16)^2=2$
9. $8x^2-15xy+8y^2+240x-256y+2046=0$
10. Join (2.8, 10.5) and (0, 15)
    Join (−2.8, 10.5) and (0, 15)
11. $y=16$ for $x=2$ to 10
    $y=16$ for $x=-2$ to -10
12. $x=y-16$ for $x=2$ to 4 and -2 to -4
13. $x=-y+16$ for $x=2$ to 4 and -2 to -4
14. $(x-1)^2+(y-11)^2=\frac{1}{4}$
15. $(x+2)^2+(y-6)^2=\frac{1}{4}$
16. $(x-3)^2+(y-7)^2=\frac{1}{4}$
17. $(x-2)^2+(y-1)^2=\frac{1}{4}$
18. $(x+6)^2+(y+4)^2=\frac{1}{4}$
19. $(x-3)^2+(y+7)^2=\frac{1}{4}$
20. $(x-8)^2+(y+4)^2=\frac{1}{4}$
21. $(x+2)^2+(y+3)^2\ \ \frac{1}{4}$
22. $x=\frac{1}{2}$ for $y=-8$ to -11
    $x=-\frac{1}{2}$ for $y=-8$ to -11
23. $64(y+11)^2+9x^2=144$
24. $x=4$ for $y=-11$ to $-\frac{23}{2}$

    $x=-4$ for $y=-11$ to $-\frac{23}{2}$

25. $64\left(y+\frac{23}{2}\right)^2+9x^2=144,\ y<-\frac{23}{2}$

26. $256(y+11)^2+36x^2=9$

MATHEMATICS FOR CHRISTMAS

JOSEPH J. URBANCEK
Chicago Teachers College, Chicago, Illinois

The solutions of the following problems should give you both pleasure and information.

1. $\_\_\_\_\_ = M \sec^2 x - M \tan^2 x$

2. $\_\_\_\_\_ = 2+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\cdots$

3. $\_\_\_\_\_ = r^2 \tan \frac{\pi}{4}+r(ax^2+bx+c)^0-rr \sin \frac{\pi}{2}$

4. $\_\_\_\_\_ = \cot \frac{\pi}{4}+r\left(\sec^2 \frac{\pi}{3}+2 \tan \frac{3\pi}{4}-1\right)-\tan \frac{\pi}{4}$

5. $\_\_\_\_\_ = y-2x-3+2x(\sin^2 x+\cos^2 x)+3 \log_y y$

6. $\_\_\_\_\_ = \sin A \csc A+C-\cot A_h \tan A_h$

7. $\_\_\_\_\_ = h \tan \frac{3\pi}{4}+h \cot \frac{\pi}{4}+h$

8. $\_\_\_\_\_ = \frac{4\pi}{3} r^3 \cos \frac{\pi}{2}-\pi r^2 h \cot \frac{3\pi}{2}+\frac{1}{2\pi h}(2r\pi h)$

9. $\_\_\_\_\_ = -i(\cos \theta+i \sin \theta)^6, \quad \text{for} \quad \theta=\frac{\pi}{2}$

10. $\_\_\_\_\_ = s\left[P\left(1+\frac{r}{k}\right)^n\right]^0$

11. $\_\_\_\_\_ = \text{Evaluate: } t\left[\frac{d(\frac{1}{3}x^3-\frac{1}{2}x^2+x)}{dx}\right], \quad \text{for} \quad x=1$

12. $\_\_\_\_\_ = \frac{2m(\csc^2 a-\cot^2 a+\sin 30^\circ)}{3}$

13. $\_\_\_\_\_ = a\sqrt{a^0+2x+x^2}-ax$

14. $\_\_\_\_\_ = \int_0^{\sqrt{s}} 2x dx$

MUSHROOMS—TO EAT OR NOT TO EAT

J. Arthur Herrick
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The fleshy fruiting bodies of fungi are most commonly known as mushrooms to the biologist or as mushrooms and toadstools to the layman. With the person who uses both names, the latter usually denoted something poisonous. Contrary to the opinions of many, most mushrooms are non-poisonous. Of the several thousand species which grow wild in the United States, only about 75 are known to be poisonous.

It is rather common knowledge that rodents, reptiles, insects and other forms of animal life commonly feed upon mushrooms. History also tells us that the human animal has prized fungi as food for many centuries. Not only has man been eating fungi down through the ages, but he has also been making fatal mistakes along the way. In spite of the fact that our ancestors have been eating mushrooms since before the dawn of history, nature has not endowed us with either an immunity to their poisons or with a protective instinct which tells us which we may safely consume. Since nature has given us an appetite for mushrooms but has simultaneously strewn the mushroom eater's path with dangerous booby traps, the popular question has become, "How can we differentiate the edible from the poisonous forms?"

The purpose of this brief dissertation is not to enable the reader to go out with his basket and safely gather a mess of mushrooms, but rather to consider the nature of both the popular and the professional answers to the above question. The reason for attempting a paper of this sort is because the writer believes that it is a responsibility of the teacher to be able to advise students intelligently about those practical questions most often asked. It should further be the responsibility of the biology teacher to disseminate those details of biological knowledge which are of vital importance to the health and welfare of the individual. All mushroom tragedies may be attributed to either ignorance or to misformation. If the two be different, it is the latter which is the more dangerous and at the same time the most easily guarded against. The development of a safe attitude may be accomplished in a matter of minutes whereas it may require years to gain a safe fund of knowledge relative to this subject. In order that we may better protect our students from malicious advice let us consider the nature of our adversary. The most common sources of misinformation are your neighbors, your friends or even the man whom you find in the woods with a basket of mushrooms, to say nothing of printed matter.

Many so-called rules for determining the edibility of mushrooms have been noted. Some of the more common dangerous ones are presented here with remarks pertinent to each:

1. *Blackens silver.* Many people seem to think that the darkening of a silver spoon when cooked with mushrooms, is a sure indication of toxicity and conversely that the failure of the silver to so respond is proof of edibility. It is fortunate that few people actually practice this method. As any elementary chemistry student knows this is simply an indication of sulfur and has nothing to do with poisons. It is, in most cases at least, due to the formation of hydrogen sulfide during the decay of older specimens and so would be lacking in any fresh mushroom, poisonous or otherwise. Since spoiling food may make one sick it is easy to see how this misconception originated.

2. *Blackens onions.* One of the writer's students reports that his family has been eating wild mushrooms for many years, and that they test each batch by cooking a small amount of onion with the fungi. Blackening of the onion, to them, means danger! Either they have been very lucky or else they have some practical knowledge which directs them during the picking operations. There is no scientific data in support of their test.

3. *Cap peels.* The fact that the cap of the familiar meadow mushroom may be readily peeled has led to the erroneous notion that this is a criterion for the identification of edible mushrooms in general. It should be remembered that some of the most deadly amanitas will peel quite as well.

4. *Growing on wood.* The writer has met persons in the woods promiscuously gathering mushrooms so long as they were growing on dead wood. It is true that most dangerous species do not grow on wood and that most mushrooms found on dead logs and stumps are safe. It should be known however, that the autumn pholiota grows only on decaying wood and has human fatalities to its credit.

5. *Eaten by immigrants.* It is commonly believed that European immigrants know their mushrooms because of the fact that their ancestors have been gathering mushrooms for generations. It should be noted, however, that the most of our cases of mushroom poisoning occur among European immigrants or their immediate associates. The frequency of mushroom poisoning the world over appears to depend largely upon the mushroom-eating habits of the people. In those countries where many mushrooms are eaten, deaths are correspondingly more common. Wolf and Wolf in a recent book (14) state that 480 deaths were reported for an eight year period in Japan; "153 fatal cases in a 2-week period in 1912 in France," as well as other figures. The implication is obvious.

6. *Eaten by wild animals.* It has even been suggested that we may safely follow the wisdom of the wild animals. That this is unsound is indicated by the fact that skeletons of the wood tortoise, which frequently feeds upon mushrooms, have been found, which upon laboratory examination were shown to contain poisons of the deadly amanita. Cows and chickens have also been killed by this same choice of food (3). Hesler (8) reports feeding poisonous mushrooms to frogs with no ill effects to the frog. Obviously we need other criteria.

7. *Taste it.* A most dangerous suggestion is that one should taste the mushroom. If it tastes all right, then eat a very small bit. If you still feel well after several hours you may consider the fungus safe. Fortunately this is not a common practice since some deadly species contain poisons which often produce no symptoms until the following day and in some of the amanitas the toxin is so potent that a small nibble could well be the final one.

8. *Milky sap.* Most latex-containing forms are non-poisonous. There are, however, dangerous species of the so-called milk mushrooms.

9. *Pink gills.* The common meadow mushroom, which is also the mushroom of commerce, in its prime condition has pink gills. With age these gills darken to almost black. Since there are other species with pink gills which are known to be poisonous, it would not be wise to depend upon gill color alone as an indication of edibility.

10. *Stalks.* The most of our edible species have stalks, but so do the most of our poisonous species. There are also choice types which grow without stalks.

11. *Fairy-ring formation.* Many mushrooms, poisonous and otherwise, tend to form fairy-rings. This phenomenon occurs because the fungus grows in all directions from its starting point and therefore may produce a circular crop of fruiting structures.

There are other less often repeated popular criteria for the selection of mushrooms but as with those above there is something wrong with every simple method for the separation of poisonous from the non-poisonous species.

The situation which disturbs the author most, however, is the frequent occurrence of dangerously loose or even incorrect statements in print. So long as we have the freedom of the press, we can expect such to continue. (The author does not mean to imply that a controlled press would be an improvement.) This situation *per se* may not be serious, but what makes it serious is the fact that the graduates of our schools all too often have the idea that anything occurring in a book or even in a magazine must therefore be the truth. To the per-

son planning to gather his own mushrooms this attitude could well prove to be his Waterloo. In connection with the teaching of Mycology (study of fungi) the writer has read many articles and books pertaining to this subject. It seems that both book and magazine writers often feel the urge to tell their fellow men how easy it is to learn the art (it should be a science) of mushroom picking. It is also obvious that no special knowledge of mushrooms is a prerequisite to the writing of such literature.

Let it be clear that there is no intent here to slander any writer or publisher since the situation here is no different than it is in many other scientific fields, which also have a high level of popular interest. As emphasized in the introduction, since human life is at stake, the writer feels that as teachers we should endeavor to teach our students a safe point of view regarding this popular question.

As would be expected, a survey of the literature on mushrooms reveals all shades of advice to the would-be mushroom picker. In general, the dangerousness of the advice is somewhat dependent upon the reader's knowledge, general intelligence, out-door experience, etc. Let us consider some selected samples and problems presented by printed matter dealing with our question.

1. *Out-of-date literature.* The case of the false morel is the most notorious. Experts uniformly agree that all true morels, or sponge mushrooms, are non-poisonous and highly prized as food. With the false morels, however, the situation is quite different and it is even possible for the novice to confuse one with the other. Marshall (11) in his once popular volume *The Mushroom Book* lists "*Gyromitra esculenta* (Edible)." In fact, the species name, *esculenta*, is a latin word meaning edible. If one will then look in the second volume of *The Fungi* by Wolf and Wolf (14) published in 1947, he will find that older specimens of this fungus contain a poison which causes a dissolution of the red blood cells of its victims. They go on to say that no less than 160 fatal cases of poisoning due to this species have been reported in the United States. Obviously it may make a difference which book one happens to read.

2. *Are Coral Mushrooms good?* A situation which is similar to the above, but less tragic has to do with the beautiful little coral fungi (*Clavaria* spp.). McCubbin (10) in his book on *Fungi and Human Affairs* states that "The Coral fungus, . . . is good to eat." Marshall (11) agrees by saying that "The novice may safely experiment with the Clavarias." If, however, you will look in Coker, *The Clavarias of the United States and Canada* (5) the situation looks a little different. Contradictory to both of the above quotations, Dr. Coker states that the Clavarias "vary decidedly in palatability, and some are apparently unwholesome" and one species "*Clavaria dichotoma* has been

reported as causing sickness." If a little can cause sickness, what would a larger serving do?

3. *Identify with a good reproduction.* One anonymous author writes (1) in a popular magazine that poisoning can be prevented by proper identification. This is very true but then he continues that "This is not difficult since many good color reproductions are available in almost any book on this subject." If you will now look in *Life Magazine* (2) you will find excellent color photographs of the deadly fly mushroom (*Amanita muscaria*) and of the "edible blushing amanita" (*Amanita rubescens*). Even though the photographs are in natural color and well taken the two pictures look identical. To avoid the objection of edible amanitas let us consider another such case. The smooth lepiota (*Lepiota naucina*) is a common edible species and yet the only obvious difference between this and the death angel (*Amanita* sp.) is that the amanita has a cup-like structure at the base of the stem which may be poorly differentiated or obscured because of its position under the leaves or within the soil layer. It is easy to miss the cup and then the deadly amanita looks exactly like the "good reproduction" of the edible lepiota. It is true that pictures may help in the process of identification, but no expert will trust them.

4. *Whom shall we believe?* That you must know your subject well is indicated by contradictions occurring in the leading up-to-date books. As an example, in the currently popular *Mushroom Handbook* by Krieger (9) we find the blushing amanita (*Amanita rubescens*) referred to as edible and to further stimulate your appetite Dr. Krieger writes "The cap eaten was quickly fried in hot butter and sprinkled with salt and pepper." But if we will look in the recent two-volume treatise on the fungi by Wolf and Wolf (14), we may read that this same species contains a hemolytic principle which causes abdominal distress, dizziness, vomiting with blood, and convulsions. Which up-to-date book shall we believe?

5. *The Meadow Mushroom.* Another professional magazine writer (2) wisely advises the novice to stick to the familiar meadow mushroom. He further recommends that you should always make a spore print because this fungus has *purple-black* spores. Just to spoil your fun, it should be remembered that the poisonous *Paneolus* also grows in the same pastures and it has *black* spores. Then if you will read a recent paper by Norton (12) you will find that this same meadow mushroom has "pink gills and brown spores." Can you tell *black* spores from *purple-black* spores, or are they brown?

6. *Ring and cup.* Perhaps the most commonly printed caution is that you avoid those fungi with a ring around the stem and a cup at the base. These are the amanitas, most of which are deadly poisonous. Beware lest you assume that all others are non-poisonous.

Such is definitely not the case. Another even greater danger lies in the fact that in many specimens the cup of the deadly amanita is below ground level or is buried in the leaves and so is readily overlooked. In others there may be little or no cup present and in old specimens the ring may all but disappear. It is therefore, easy to pick an amanita by mistake if you blindly follow the above rule. Some have the idea that the poison is restricted to the "death-cup." Actually all parts are equally poisonous.

By now the reader may wonder if there is any safe advice in the mushroom literature. The answer is yes, and it often occurs in the same books and articles along with some of the above recommendations. Some of the statements upon which all mycologists agree are presented here.

1. *All morels are safe and good.* Just be sure you get no false morels (see discussion above).

2. *All puffballs are safe.* Cut each specimen with a knife so as to make sure that it really is a puffball and not a "button" of some poisonous gill mushroom.

3. *Never collect any mushroom in the button stage.* Buttons can not be identified accurately.

4. *All white toothed fungi are safe.*

5. *Commercially grown mushrooms are as safe as any other grocery-store food.*

As a closing section let us consider what some of the leading authorities say about mushroom picking and eating in general.

In a publication by the U.S. Department of Agriculture, Charles (4) makes an urgent appeal that the collector "*abstain from experimenting with or eating any mushroom unless he is absolutely certain of the identity and edibility of the species collected.*" The advice from the famous Chicago Museum of Natural History as stated in Graham's mushroom manual on the "Mushrooms of the Great Lakes Region" (6) is "*that not less than two years be spent in such intensive study that a great many species may be recognized at sight before any student begins to eat the less familiar kinds of wild fungi.*" Marshall (11) is more general and writes that "*There is no general rule by which one may know an edible species from a poisonous species.*" The government experts in Canada (7) have made their admonition brief and clear. Their advice is that you "*eat no fungus of any kind unknown to you.*" The same or similar ideas occur in most published works dealing with mushrooms as items of human food. If the mushroom lover can become adequately inoculated with these final quotations of mushroom wisdom he will subsequently be immune to the dangers of infection by the various species of malicious advice discussed in most of this review.

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THE QUIZ SECTION

JULIUS SUMNER MILLER
Michigan College of Mining and Technology
Sault Ste. Marie, Michigan

1. If a uniform sphere rotating about a diameter contracts by cooling, show that when its radius is reduced to $1/n$th of its former value the kinetic energy is multiplied by n^2.

2. If the radius of the Earth is diminishing as time advances find the effect of the contraction on the length of the day. Assume the contraction proportional to the time and assume uniform density.

3. Show that if an elastic string (or a coil spring) is stretched an amount d by the *gradual* application of a load the extension would be $2d$ if the load were *suddenly* applied.

4. A wheel is rolling along a horizontal road with constant velocity and a piece of mud is thrown off its hindmost point. Will the mud touch the wheel again? Prove it. Where?

5. If a wheel is rolling along a horizontal road is there any point of the rim which has a velocity which is straight up or straight down?

6. A man goes a distance d miles at a uniform rate of 30 mph. QUICKLY NOW, at what average or uniform rate must he return to average 60 mph for the total trip?

Microfilm recorder has a mirror reflex system which makes it possible to photograph both front and back of a document at the same time, and places the two images side by side on 16-mm. film. For single document recordings, one half of the film width can be used at a time.

GEOMETRIC ILLUSTRATIONS IN TEACHING ALGEBRA II

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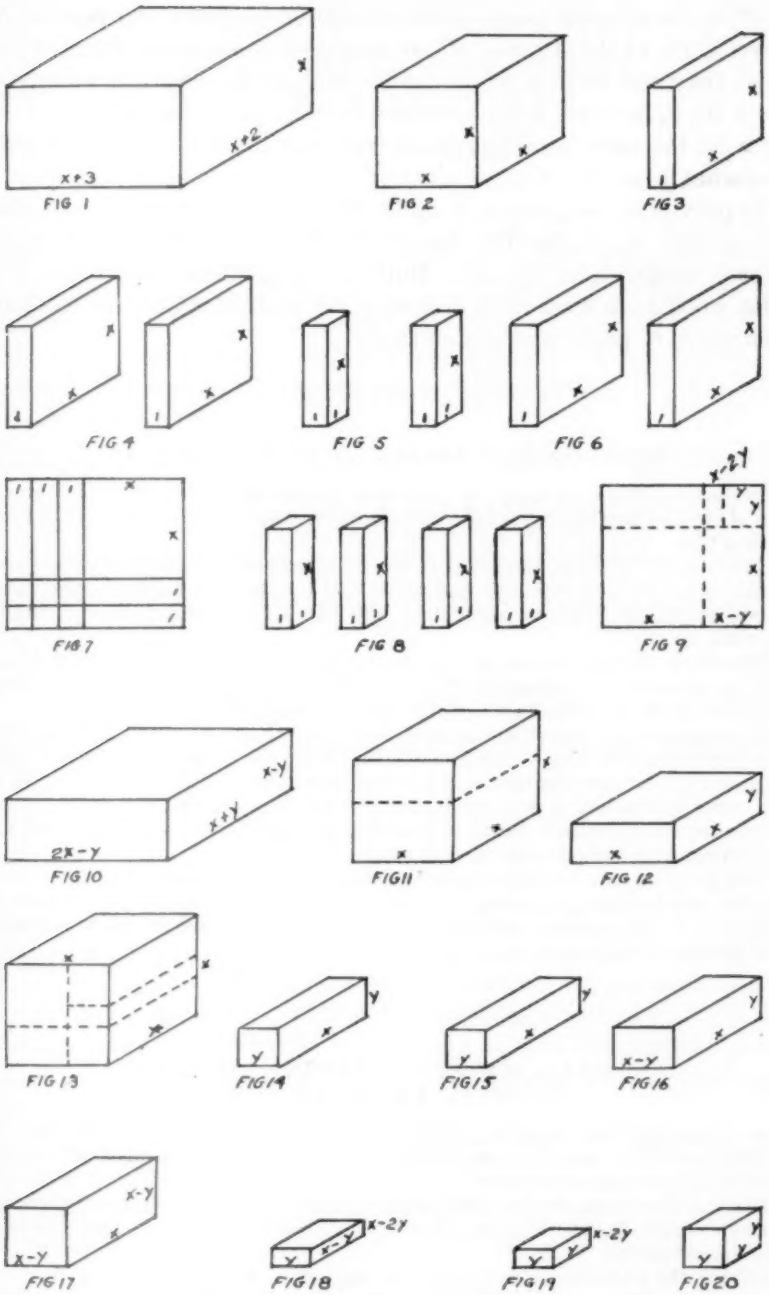
A previous article on this subject (see SCHOOL SCIENCE AND MATHEMATICS, December 1947) treated algebraic products of second degree. Useful as illustrations of second degree expressions may be, to stop there would leave the teacher in a potentially embarrassing position because the most elementary treatment of algebra takes one into polynomials of third and fourth degree; and if illustrations are used in second degree some student will ask to see them in higher degrees. The student's question is the teacher's opportunity—if the teacher is prepared. Toward that end this article is written.

Algebraic expansion of the factors $x(x+2)\ (x+3)$ gives the trinomial x^3+5x^2+6x. If the factors x, $x+2$, and $x+3$ are taken as the dimensions of a rectangular solid an object such as figure 1 results. (Any value may be assigned to x as also may any suitable length be chosen for the value of the unit used to express the 2 and 3.)

If, also, solids are made to scale to represent each of the terms of the trinomial, there would be twelve in all. There would be one cube x on an edge (volume x^3) see figure 2. There would be five solids x by x by 1 (volume x^2) see figures 3, 4, and 6; and six solids x by 1 by 1 (volume x) see figures 5 and 8. If these solids are arranged as shown in figure 7 (top view) they will form a rectangular solid exactly equal in volume to figure 1.

Another effective method of comparison is to make figure 1 a hollow box with open top and inside dimensions equal to the given factors. The twelve solids will then fit snuggly into the box with top view as shown in figure 7.

The foregoing was an illustration of an expression consisting only in the sums of terms. Let us now consider the product of the binomials $(2x-y)\ (x+y)\ (x-y)$. Expansion of these factors gives us $2x^3-x^2y-2xy^2+y^3$. The rectangular solid whose volume is the product of the binomials is shown in figure 10. Figures 11 and 13 are the two cubes x on an edge. According to the polynomial we must subtract x^2y (see figure 12) from one cube and $2xy^2$ (see figures 14 and 15) from the other. Figure 12 is cut off figure 11 as shown by the dotted line. Figures 14 and 15 are cut from the upper right and lower right sections of figure 13. Figure 16 is the lower left portion of figure 13; it must be cut off for purposes of rearrangement but is not to be subtracted from the volume of the cube. Figure 17 is the upper left portion of figure 13. The center right portion of figure 13, cut at $x-y$



distance from one corner gives figures 18 and 19. This cut is necessary for rearrangement. Figure 20 is a cube y on an edge as represented

by y^3 in the original polynomial. If figures 11 (with top portion removed), 16, 17, 18, 19, and 20 are arranged as shown in figure 9 (top view) they will form a rectangualr solid exactly equal in volume to figure 10. (The exact solution shown here is applicable only if $y < .5x$; if $y > .5x$ the same principles hold true, but the solution would differ somewhat.)

As previously suggested, if figure 10 is made as an open box, then with a little sand papering, figures 11, 16, 17, 18, 19, and 20 can be slipped snugly into the box. Both of these models were made of balsa wood by a student in first semester algebra. Other models have been made of paper and scotch tape.

DEVELOP NEW SERIES OF 15 MICROSCOPES

Production of a new series of wide-field microscopes that provide a greater field of observation than ever before attained, was announced by Bausch & Lomb Optical Co.

Consisting of 15 basic models that can be interchanged into 58 different combinations for medical research, industrial and educational purposes, the microscopes' optical systems are completely sealed to prevent dust from reaching the interior.

Dissecting microscopes are now available with an extra large stage and base, while an elaborate instrument is offered to industry for use in surface examination. With the latter, a circular area of five feet in diameter may be inspected.

All eyepieces and objectives are of new design. The objectives minimize image deterioration at the edge of the field of view, while the eyepieces provide a higher eye point for greater comfort, and prevent interference with glasses, should the user wear spectacles. A dust-proof, sliding nosepiece on three-objective models offers a rapid, convenient means of interchanging objectives, and insures viewing the subject with but one objective at a time.

Four positions are provided for a new illuminator and fluorescent lamp, to enable the microscopist to arrange his lighting as a photographer would to suit his subject. The microscopes are equipped with diffusing discs of black and white that provide background contrast.

FIELD MAPPING MACHINE CHARTS INVISIBLE FIELDS OF FORCE

An automatic field mapping machine which has nothing to do with the work of land surveyors may find important laboratory uses, General Electric Company scientists predicted today.

The machine maps the invisible field of force surrounding electrically-charged pieces of metal. It was developed here by General Electric, but is not yet available commercially.

Solving the problems in such fields as magnetics, fluid streamlining, heat conduction and airplane propeller blade torsion may be speeded by the new device.

Metal specimens are connected to a power supply and placed in water for tests with the mapping machine. Three tiny probes register the voltage, while the motion of the probes is recorded as lines on a drawing board by a four-foot metal arm.

SOME ANALYTICAL MECHANICS OF THE AUTOMOBILE

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While investigating certain principles in analytical mechanics, particularly the statics and dynamics of rigid bodies, the author's attention was drawn to the applicability of these principles to the automobile. Out of a heterogeneous array of inquiries a few of the more common questions were precipitated and it was felt that these possess some interest for the readers of this Journal. The following questions were formulated:

1. For a given coefficient of friction what is the maximum acceleration which a car can have?
2. Will rear-wheel or front-wheel drive provide greater propelling force?
3. Will rear-wheel or front-wheel brakes provide greater braking "power"?
4. At what acceleration will the car be on the verge of tipping over backwards?
5. At what deceleration will the car be on the verge of tipping over frontwards?
6. On a curve with no banking at what speed will the car be on the verge of turning over?
7. On a banked curve what are the possibilities?
8. In going over an arched bridge at what speed will the wheels just cease to stay on the road?
9. With the car at rest on a hill which brakes are more effective, the front ones or the rear ones?

We proceed to examine some of these situations.

I. MAXIMUM ACCELERATION

Let the car of weight W have a wheelbase B feet, be rear-wheel driven, with center of gravity h feet above the road level. The forward force F is developed by the friction between the rear wheels and the pavement. When the car is accelerated the reaction on the front wheels is decreased and that on the rear wheels is increased in the same amount. Let this be w. It is given by the equation $Fh=wB$. That this is so can be shown as follows:

Let the center of gravity of the car be distance b from the rear wheels and distance c from the front wheels. ($B=b+c$.) Then for static equilibrium the reactions at front and rear wheels are given by the equations

$$R_F \cdot B = W \cdot b \quad \text{and} \quad R_R \cdot B = W \cdot c.$$

When acceleration takes place, a force Wa/g acts at the center of gravity of the car and for dynamic equilibrium we now write

$$R_F \cdot B + \frac{Wa}{g} \cdot h = W \cdot b \quad \text{whence} \quad R_F = \frac{Wb}{B} - \frac{Wa}{g} \cdot \frac{h}{B},$$

$$R_R \cdot B - \frac{Wa}{g} \cdot h = W \cdot c \quad \text{whence} \quad R_R = \frac{Wc}{B} + \frac{Wa}{g} \cdot \frac{h}{B},$$

from which it is seen that the acceleration contributes to an increased reaction at the rear wheels and a diminished reaction at the front wheels, of equal amounts. On the strength of this it may be concluded that the rear-wheel drive provides a greater driving force and similarly, that front-wheel brakes provide a greater braking "power."

It might here be parenthetically stated that the effectiveness of the brakes is, in truth, dependent upon the wheels turning. That is to say, the brakes are only effective while the wheels revolve. The kinetic energy of the vehicle is obviously dissipated at the brake bands and the brake shoe, and in friction against the roadway. If the rotation of the wheels is completely arrested the only friction available is that between wheel and road, whereupon sliding or skidding results. If the coefficient of friction at the brake shoe and drum is the same as that between wheel and road, the brake-shoe action (thrust) must obviously be less than that of the wheel on the roadway. If it is not, skidding is inevitable. The limit of breaking action (usefulness) is that at which the wheel skids.

We might here expediently dispose of one or two simple and erroneous notions. One is the idea that *wide* brake bands are more effective than narrow ones having less surface in contact with the drums. This is not so. Their only claim to more effectiveness is longer wear. Another erroneous notion is that a heavy car requires greater distance for stopping than a light car. This again is not so. Finally, it can be easily shown that the stopping distance varies as the square of the velocity and hence becomes dangerously great at high speeds. At 60 mph the stopping distance is four times that at 30 mph. Accordingly, to impress the reader, consider a car travelling at 30 mph. Allow a coefficient of friction on the roadway of 0.8. (This is an extremely high figure for rubber tires on the usual cement road.) If all four wheels were locked, which, of course is an extremely dangerous state of affairs, the minimum stopping distance is about 40 feet. At 60 mph this distance is about 160 feet.

Returning to our analysis above, let W_R and W_F be the weights on rear and front wheels respectively. With the rear wheels driving we then have

$$F = \mu(W_R + w) \quad \text{whence} \quad w = \frac{F - \mu W_R}{\mu}.$$

Using our first equation we have

$$F=\frac{\mu W_R B}{B-\mu h}.$$

The maximum acceleration available then is

$$a=\frac{F}{W/g}=\frac{\mu W_R B g}{(B-\mu h)(W_R+W_F)}.$$

Starting at rest, the velocity attainable in a time t is clearly

$$v=\frac{\mu W_R B g}{(B-\mu h)(W_R+W_F)}\cdot t.$$

The distance passed over in this time is

$$s=\frac{1}{2}\ \frac{\mu W_R B g}{(B-\mu h)(W_R+W_F)}\cdot t^2.$$

Conversely, the time to acquire a speed V is

$$t=\frac{V(B-\mu h)(W_R+W_F)}{\mu W_R B g}=\frac{V}{g}\left(\frac{B-\mu h}{\mu B}\right)\left(\frac{W_R+W_F}{W_R}\right)$$
$$=\frac{V}{g}\left(\frac{1}{\mu}-\frac{h}{B}\right)\left(1+\frac{W_F}{W_R}\right),$$

and, obviously, the distance traversed in this time is

$$s=\frac{V^2}{2g}\left(\frac{1}{\mu}-\frac{h}{B}\right)\left(1+\frac{W_F}{W_R}\right).$$

Now, when the car is being brought to a stop, the rear wheels are braked, and the retarding force F contributes to an increased reaction at the front wheels and a diminished reaction at the rear wheels in accordance with the principles above. ($Fh=wB$.) The retarding force *now* is given by

$$F=\mu(W_R-w)$$

which gives

$$F=\frac{\mu W_R B}{B+\mu h}.$$

The time to lose the speed V is then given by the equation above, with appropriate change of sign, as is also the distance to stop. That is,

$$t=\frac{V}{g}\left(\frac{1}{\mu}+\frac{h}{B}\right)\left(1+\frac{W_F}{W_R}\right)$$

and

$$s=\frac{V^2}{2g}\left(\frac{1}{\mu}+\frac{h}{B}\right)\left(1+\frac{W_F}{W_R}\right).$$

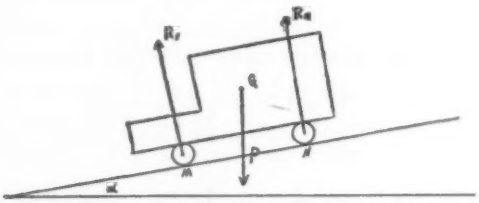
II. Braking on a Hill

We are to determine which wheels, front or rear (F or R), provide greater "holding."

The motion of a wheeled vehicle on an inclined plane involves some rigorous and complex inquiry beyond the limits of this paper. For example, the effective inertia of a car of weight W with four wheels each of weight w, radius of gyration K and radius R can be shown to be

$$W+4w\left(\frac{R^2+K^2}{R^2}\right),$$

and the dynamics involves the translational energy of the whole system together with the rotational energy of the wheels. We accordingly simplify our treatment by considering the car at rest. Diagrammatically we approximate the situation thus:



The diagram is self-explanatory. The plumb line through the center of gravity G cuts the plane in P. With the car at rest the reactions at the points of contact of wheels and ground are R_F and R_R. In limiting equilibrium then, the frictional force is either uR_F or uR_R according as the front or the rear wheels are locked. If we take moments about P we have, for equilibrium,

$$R_F \cdot MP = R_R \cdot NP.$$

Hence R_F is greater or less than R_R according as MP is less or greater than PN. In general, MP is less than PN. Since uR_F or uR_R holds the car it appears that when the car is at rest it is more easily held when the front wheels are braked. A given coefficient of friction admits of the steepest slope then when the front wheels are locked. It is clear that the lower the center of gravity the less the difference between front and rear wheel braking. If a vector diagram is made for

each case the forces can be shown to be concurrent in a point *above* the plane when the front wheels are locked and concurrent in a point *below* the plane when the rear wheels a.e locked.

III. Tipping Over Backwards or Forwards

If we assume adequate frictional forces and sufficient power to develop the acceleration, it is simple to show that the maximum allowable acceleration is given by $a = gb/h$ for tipping over backward. Similarly, for tipping over frontwards we have gc/h, where b and c are defined as before, namely, the lengths in which the wheelbase B is divided by the plumb line through the centroid.

IV. Travel on a Curve— No Banking

We consider here a level road, the center of gravity of the car of weight W describing a circle of radius R with speed V. The central force, from elementary considerations, is WV^2/R, and this is supplied by the action at the ground. For slipping to impend at a speed V we simply equate centrifugal force to frictional force which yields the speed V at which the car will be on the verge of slipping. Thus: $mV^2/R = umg$. For tipping the following analysis holds: As before, let h be the height of the center of gravity and let L be the width between wheels. Let P be the upward force on the inner pair of wheels; Q the upward force on the outer pair of wheels. Taking moments about P we have

$$\frac{WV^2}{R} \cdot h + W \cdot \frac{h}{2} \cdot g = Q \cdot L$$

and for moments about Q we have

$$P \cdot L + \frac{WV^2}{R} \cdot h = W \cdot \frac{h}{2} \cdot g$$

whence

$$P = \frac{W}{L}\left(\frac{RLg - 2V^2h}{2R}\right)$$

and

$$Q = \frac{W}{L}\left(\frac{RLg + 2V^2h}{2R}\right).$$

According to this we see that when $2V^2h = RLg$, the inner wheels are on the verge of leaving the ground and tipping over is imminent. Hence at $V = \sqrt{RLg/2h}$ the car is about to tip.

V. Travel on a Banked Curve

Let the angle of bank be θ, measured from the horizontal. The car has a weight W and is traveling with speed V on a radius R. There are several cases to be considered.

(1) When skidding sidewise is not impending the reaction of the road is normal to the plane and this reaction, Q say, is the resultant (equilibrant) of W and WV^2/gR, so that $\tan\theta = V^2/gR$, as is readily seen from a vector diagram. The reaction Q passes through the center of gravity and its line of action falls *between* the wheels.

(2) If the car is on the verge of skidding, the reaction Q makes an angle α with the normal to the plane ($\mu = \tan\alpha$), and a vector diagram shows $\tan(\theta+\alpha) = V^2/gR$. The line of action of Q still falls *between* the wheels.

(3) If the car is on the verge of tipping over (outward) the reaction Q is at the outer wheels only, and its line of action now passes through the contact point of outer wheels and road. If this reaction makes an angle β with the normal to the plane a vector diagram shows $\tan(\theta+\beta) = V^2/gR$. If, as before, the center of gravity of the car is at a height h and the width between wheels is L, then $\tan\beta = L/2h$.

(4) If the car is on the verge of tipping over (inwards), then $\tan(\theta-\beta) = V^2/gR$.

It is clear that in all cases the angle is proportional to the square of the velocity and inversely as the radius. A fixed "bank" is designed to suit the "average" speed on the curve and cannot, obviously, meet the requirements of speeds lower or higher. In railroad engineering the flanges on the outer wheels provide the centripetal force. It might be well to add that there is no more tendency, nor no less, for a heavy car to skid than for a light one, and that skidding is not diminished by lowering the center of gravity, as is sometimes erroneously thought. In bicycling the "lean" of the cyclist on a horizontal track is equivalent to inclination of the track.

VI. The Arched Bridge

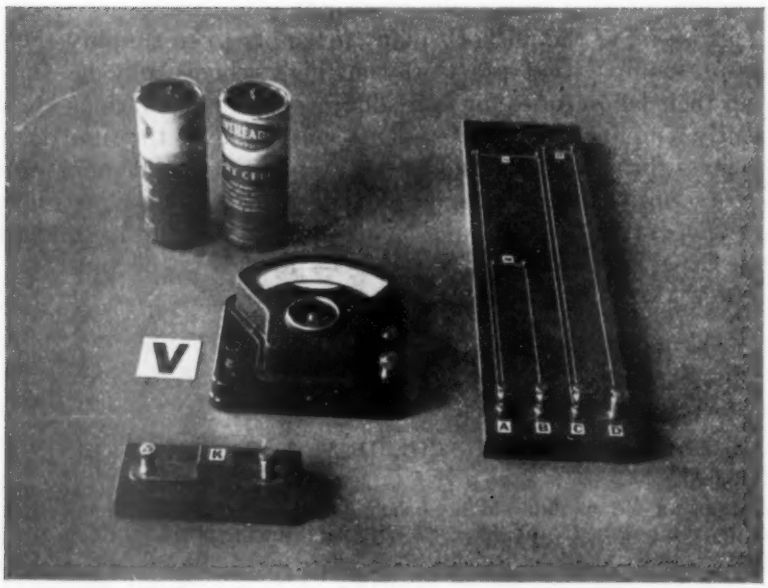
A car traveling at a high speed over the convex part of an arched roadway sometimes fails to "hold to the road." This is experienced often by drivers, and momentarily the car is out of control since the wheels at this instant cease to press on the roadway. In the case of a circular arch of radius R it is easily seen that the condition to be fulfilled is given by $MV^2/R = Mg = W$, whence $V = \sqrt{gR}$, the speed beyond which the wheels cease to push on the road. If the curve trav-

ersed is not a circular arc then R is the radius of curvature at the highest point. The calculus provides a general formula for the curvature which then may be found from the equation of the curve. Thus, an arch may be parabolic; it may be a portion of a sine or cosine curve. In any case the critical velocity may be found. It decreases with the "abruptness" of the arch.

A converse situation obtains when "dips" are encountered on the road, such as occur with great frequency on western desert highways. Here the thrust on the wheels as they pass the lowest point of the dip is multiplied several-fold over the gravity force W of the car. Even for the low spots in the road the maximum thrust may be dangerously large and the importance of springs between body and wheels becomes obvious.

A COMBINATION RESISTANCE BOARD AND RESISTANCE BOX

H. CLYDE KRENERICK
Milwaukee, Wis.



The lengths and the diameters of the wires have been so selected that the board may be used not only for the demonstration of the laws of resistance, but as a resistance box containing the known resistances needed for all experiments in electrical measurements.

Wires *m* and *n* have the same diameter but differ in lengths. Wires *n* and *r* have the same length but differ in diameters. The student first determines the resistance of the three wires by the volt-ammeter method and discovers the relation between the resistance of a conductor and its length and its diameter. The specific resistance of German silver may also be determined.

When the student is through with these experiments, he is given the correct resistances of the three wires (*m* has 1 ohm, *n* 2 ohms and *r* 5 ohms). With the use of the board, several known resistances (1, 2, 3, 5, 7, 8, .67 ohms) may be placed in a circuit. The resistance used depends on the binding posts connected instead of the plugs removed. The percentage of error is so small that it can not be detected on a 10 or 15 range meter.

Contrary to the usual practice, two separate meters, a voltmeter and an ammeter, are not necessary. It is far more instructive to the student if he first connects his circuit, series or parallel, and then connects the meter to determine the amperage at some point of the circuit, and then reconnects to determine the voltage or pressure between two given points. This gives the student a better idea of the difference between an ammeter and a voltmeter connection, or a better idea of what he is really measuring.

This is one of the author's many attempts to so simplify the apparatus required that practically all high schools may be able to equip their laboratories for individual work. The operations are sufficiently simplified that the students may discover the fundamental principles through their own unaided preparation and demonstration. The descriptions of the new forms of apparatus and the instructions for the operations of the experiments have been published under the title, Experiential Physics. See its Book Review in the June SCHOOL SCIENCE AND MATHEMATICS.

MILDEW-PREVENTING CHEMICAL LOCKED INTO LINENS

Mildew-preventing chemicals may be effectively locked into linens by modification of an old method for fire-proofing textiles. Three hundred pounds of laundry can now be treated for a few cents, and the life of the fabric greatly prolonged.

The process was developed by Monsanto Chemical Company working in cooperation with Morgan Linen Service Company. It can easily be adapted to normal commercial laundry washing procedures.

A concentrated solution of sodium pentachlorophenate, a water-soluble fungicide, is basis of the treatment. The treating bath is prepared by adding eight ounces of an approximately 30% solution of the chemical to about 40 gallons of water in a standard wood washer. Clothes to be treated are rinsed in this solution for five minutes.

GEOGRAPHY IN FARWESTERN INSTITUTIONS OF HIGHER LEARNING*

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Geography as a college subject is fairly well recognized in the western third of the United States. In the eleven westernmost states, included in the area of this survey, there are 191 institutions of higher learning comprising 14 major universities, 74 colleges and minor universities, 22 colleges of education and 81 junior colleges. Geography, at least to the extent of one service course, is offered by 114 or 60 percent of these institutions. Of the state universities, 12 recognize geography and only two (Arizona and Wyoming) offer no geography. Incidentally both Arizona and Wyoming have strong geology departments which do offer a course in geomorphology. Of the 74 colleges and minor universities, 32 offer at least one course in geography, with the best showing made by the state colleges that formerly were classified as teacher training institutions. Of these 32 colleges, seven give one service course and five offer two service courses for either the school of commerce or teacher training. All of the colleges of education and normal schools offer geography, although it is seldom required for graduation and five of the 22 teacher training institutions offer only one course in geography.

In 1947–48, there were 30 institutions giving sufficient work for a major or minor in geography for the AB degree. They consist of ten major universities, eight colleges and minor universities, and 12 colleges of education. In these 30 institutions, separate Departments of Geography are found in 17, including six major universities, five colleges and minor universities, and six colleges of education. In the junior college fields, California sets a remarkable standard, with 40 out of the 45 recognized junior colleges in the state listing from one to eight courses in geography. In the other ten states there are 36 junior colleges, of which eight schools offer one or more courses in geography.

Where geography is not a separate department, it is most often included with geology or with social science. Of all institutions offering three or more courses in geography and not having a department of geography, 22 colleges of liberal arts or of education and most of the junior colleges include it with social science, 13 colleges have geography in geology or geology-geography departments and three in that of earth science. Geography is in two science departments, two

* Presented before the Association of Pacific Coast Geographers, Berkeley, California, June 24–25, 1948.

of economics and in one each with business administration, foreign trade, and a school of humanities.

Purposes of Geography

There are several purposes of geography instruction in western colleges. One is the training of teachers at various levels, elementary, secondary, and college. Another purpose is the training of students for serving in special fields such as: meteorology, soil conservation, foreign trade, and the diplomatic service. Geography also is taught as a requirement or service subject for schools of business administration, journalism, area studies, or education. Another purpose is the cultural one of explaining the landscapes, the relation of peoples and industries to their environment, the basis of international problems and other useful relationships.

Curricula

The work given in geography can be classified into: foundation or general, service, regional, systematic and technical courses.

Students taking geography in college commonly begin with a course on the principles or elements of geography. Most institutions also include a course on economic geography and some offer a world survey or global geography.

Service courses consist most frequently of economic geography for students in business, geography methods or techniques for teachers, but at the University of Washington a general course in geography for students of journalism is offered. Summer workshops in geography are offered by several colleges of education. In some institutions a term of geography is included in social science survey courses that are primarily for Freshmen and usually last an entire school year. Geography of continents, parts of continents or countries may be offered in connection with area studies where such majors have been introduced into the curricula.

Regional Geography

The core subjects for a major in geography for the AB degree are regional courses, generally one continent to a course, although in the larger departments the continent studies may be subdivided. The continents of North America, South America, Europe and Asia, or their sub-divisions, are almost universally taught in all institutions giving sufficient work for a major or minor in geography. Africa, Australia and the Pacific are taught in only one teacher training institution in the eleven farwestern states. Isn't the Pacific area important to our future teachers? Africa is listed as a course in only five farwestern colleges and universities, showing the small importance

paid to that continent. The same omission is true of the Pacific area which we adjoin; only six universities or liberal arts colleges offer any course on Australia, Pacific or Pacific Islands. As members of the Association of Pacific Coast Geographers this would seem to be a situation that we might help to change. That only seven institutions in the eleven westernmost states teach "Geography of the Pacific" seems inadequate. A course on the U.S.S.R. is taught in three universities and two colleges of education and doubtless will be added to the curricula in more departments of geography in response to interest in the subject.

There is a tendency to subdivide regions and to make courses descriptive of such smaller areas. Thus a school that once gave a single course on Asia may now offer courses on Soviet Russia, Fareastern or Southeastern Asia, Southern Asia and the Near East. The same tendency is noted in regard to subdivisions of Europe. A course in North America has been often divested of Mexico, Central America and the Caribbean islands which are either included in Latin America or a separate Middle America, or Geography of the Caribbean course. Two schools, Fresno State College and Eastern Washington College of Education offer a course on outlying possessions of the United States and San Jose State College gives one on Europe Overseas. Eastern New Mexico College at Portales offers "Geography of the Holy Land," and Colorado State College of Education, Greeley, lists "Geography of the Rocky Mountains". Many of the institutions give a course of local interest on the geography of their state or region. In the three northwestern states the "Geography of the Pacific Northwest" is commonly substituted for state geography, in part because a textbook prepared by 30 different authors is available on the subject.

Systematic Geography

Systematic courses form a part of all well rounded curricula in college geography and include subjects of both physical and cultural character.

The physical systematic courses deal with the atmosphere, climate and surface features of the earth. Generally meteorology and climatology are taught in departments of geography and this field has been one of major importance at the University of California, Berkeley. In three institutions there are separate departments of meteorology. The one at California Institute of Technology is the oldest and is of interest because it developed independently, no geography being taught at Cal Tech. Unfortunately this work will be discontinued in 1949 at Cal Tech. The University of California, Los Angeles, also has a notable department of meteorology with six full time members and

two additional lecturers. They offer 21 courses, several of which are wholly for graduate students. The latest university to establish a department of meteorology and climatology is the University of Washington, which recognized this field in the fall of 1947. Physiography is widely taught by departments of geography or geology-geography. In several institutions departments of geography encourage geography students to take beginning geology where that subject is offered, instead of teaching physiography or geomorphology within geography itself.

Cultural systematic courses have received wide recognition in geography curricula. Conservation of resources is widely taught and is listed by 16 institutions which give a major or minor in geography. Denver University gives a separate course on "Geography of Water Resources." No doubt some treatment of conservation is included in some of the courses offered by most of the institutions which do not list it as a course.

Political geography is also well represented, some 12 institutions offering the subject. There has been a movement away from offering courses in the general field of geographic influences, only six departments of geography still list geography in American History, and two the influences of geographic environment. The University of California, Berkeley, lists "Historical Geography of the British Overseas." Courses offered sparingly, mainly by the larger departments of geography, include: world trade, geography of airlines, trade centers or urban geography, agricultural geography, industrial geography, land planning and courses in geographic thought or theories. The University of Washington lists a course in mountain geography. Anthropology is taught in a few departments. A contrast in nomenclature occurs between a course on "Strategic Minerals" offered by Eastern Washington College of Education and "Geography of Peace" offered by Denver University. Plant and animal geography are given by the University of California, Berkeley.

Departments of geography at the graduate level commonly include several seminar and research courses. Some colleges offer readings in geography or opportunities for individual study.

Technique Courses

Courses that provide practice in use of the tools of geography are commonly included in a department's offerings. The fundamental technique courses are: cartography including graphics, and map interpretation or map reading, and are usually required of majors in geography. Cartography is offered by 13 institutions and map interpretation by 14. In about half the cases either both subjects are listed

at the same institution or more than one course is offered in cartography. The University of California offers in cartography in addition to beginning courses, one in topographic photo interpretation and one in map history and map appreciation.

Colleges and universities giving graduate work provide their graduate students with practice in field work and mapping. Sometimes there is a special course in the subject, more frequently the student learns field methods by working under supervision of a faculty member while collecting material for his thesis. Most theses for both the master's and doctor's degrees in geography at farwestern institutions require field work. Only a few colleges that offer no graduate work in geography give a course in field methods, but it is done occasionally.

Many colleges require a day field trip or two of beginning students. A few colleges and universities require a certain amount of laboratory work in geography.

Field trips or field courses, lasting from a week to several weeks in length, have been offered by departments of geography at several institutions including: University of Washington, Oregon State College, Eastern Washington College of Education, Central Washington College of Education, University of California, Berkeley, Fresno State College, North Idaho College of Education, University of Utah, University of Oregon, San Diego State on the home area, New Mexico College of Agriculture, and Eastern New Mexico College (Portales). These courses are commonly intended for the benefit of teachers attending the summer session, but those from the University of California have carried on intensive research in anthropology and local field geography.

Several colleges, especially the colleges of education, include courses for teachers in the techniques and source materials of geography. Several teacher training institutions have given workshops on the resources of certain geographic areas, or in conservation, or other fields, for the benefit of teachers during summer sessions.

Degrees in Geography

The Ph.D. degree in geography can be earned at three universities: California at Berkeley, California at Los Angeles, and Washington. Eastward from these three Pacific Coast universities the first department of geography granting the Ph.D. is the University of Nebraska. Since its start the department of geography at the University of California, Berkeley, has granted 20 Ph.D. degrees and that at the University of Washington, 7 doctorates in geography. None has yet been recorded at the University of California, Los Angeles, because that institution only was granted the privilege of giving the doctorate in

geography in 1947. At present, candidates for the Ph.D. degree in geography number three at the University of California, Berkeley, two at the University of California, Los Angeles, and eight at the University of Washington, of whom four have doctoral dissertations in process.

The master's degree in geography has been granted from at least six universities or colleges. In addition to universities that grant the doctorate, master's degrees in geography have been granted from the University of Colorado, University of Oregon and Brigham Young University. It is probable that a few other institutions will begin to give master's degrees in geography within the next several years. The candidates for master's degrees in geography are numerous. According to replies received from departments of geography in the eleven westernmost states included in this study, there were at least 112 students who had received the master's degree in the past and at least 45 candidates for this degree enrolled at present. By the end of 1947 master's degrees in geography had been granted as follows: University of California, Berkeley, 36 (divided into 29 Masters of Art and 7 Masters of Science); University of Washington, 36, University of California, Los Angeles, 18; University of Colorado, 19; Brigham Young University, 3; and about 10 from the University of Oregon.

The colleges of education in the state of Washington were granted in 1947 the right to offer master's degrees in the field of education, and in this case a degree would be given for geography only as a phase of education. None have yet been granted but there is one such candidate at Eastern Washington College of Education. The Colorado State College of Education, Greeley, is in the same position. None of the state colleges in California grant master's degrees in geography.

The number of courses offered in geography has a general correlation with the type of degrees granted. At the top are the three universities offering the Ph.D. degree in geography: Washington once listed 51 courses, of which seven have now been removed to the new department of meteorology and climatology, University of California, Los Angeles, has 41 courses and University of California, Berkeley, 34. Among those that grant only the master's as their graduate degree: the University of Oregon offers 23 courses, Brigham Young 22 and Colorado 15. Among those giving an A.B. degree, with a major or minor in geography are: San Diego State 15, Stanford University 15, University of Southern California 15, Fresno State 14, Greeley State 14, University of Utah 14, Eastern Washington College of Education, 21 courses, Central Washington College of Education 16, Tempe State 12, State College of Washington 11, North Idaho College of Education 11, Chico State 11, Flagstaff

State 11, San Jose State 10, and Eastern New Mexico College (Portales) 10. The highest number of geography courses listed in Junior Colleges are: Los Angeles City College 8, Santa Ana 7, Sacramento 5, and East Los Angeles 5.

Theses Subjects

The scope covered by the theses in geography indicate to a considerable degree the interests of the departments in different institutions. Most common subjects are in the fields of economic geography, regional geography, land utilization, urban studies and climatology but many more phases of geography have been represented.

At the University of Washington, theses most frequently deal with local areas. In a list of 32 master's theses titles furnished by Dr. H. H. Martin, there were 23 dealing with the Pacific Northwest, most of them in the State of Washington. There were 11 theses about valleys or districts in Washington, for example, "Historical Geography of the Snohomish Valley," "Geography of the Wenatchee River Basin" or "Irrigation Agriculture in the Yakima Valley"; four county studies, like, "Land Utilizations in Boundary County, Idaho," four urban studies like "Geography of Spokane," in two cases islands were the unit—for example, "Geography of Whidby Island," and two were miscellaneous in character, such as "The Southern Appalachian Highlanders in Western Washington." Other theses were written on subjects selected in Japan, Texas, Canada, Argentina and the New Hebrides. Emphasis is placed on field work. The only dissertation based exclusively on library work was one on "A Critical Bibliography of African Topographic Maps." Dr. Martin states in a personal communication "We are trying systematically for gradual coverage of the Pacific Northwest, using in each case a student who already has a working knowledge of the home valleys, city or county. We are confident that this is sound graduate work." Martin further states (personal communication) "You will notice that we do not believe in library theses any more than we value library dissertations. Of approximately 35 M.A. theses completed in the past, only one has been dug out of the files" . . . this being entirely based on the Army Map Library . . . "All of the others have been sent out on the land to get their stuff in part off the grass roots. In a number of cases a student has dug it out abroad, i.e. . . . on a summer trip to Japan, . . . in the Argentine, from experiences in the New Hebrides, etc. This coming summer a man, adept in Spanish, is going to Costa Rica."

Of the seven doctoral dissertations at Washington three have been in the field of climatology, two on land utilization, and one each on fisheries and population distribution. Of four dissertations in process

two are on land utilization around Grays Harbor and Truckee-Carson project respectively, one on Tillamook, Oregon, and one on "Historical Geography of New Zealand."

At the University of California, Berkeley, doctoral dissertations and master's theses have covered a wide variety of subjects. Present dissertations of three candidates for the doctorate are on: Geomorphology of the Cape Area, Baja California, the San Joaquin Valley, and Fishing Among Primitive Peoples. In the past, several dissertations have been in the field of climatology. Master's theses for the current year include: three on geomorphology, of which one is on "Present Glaciers of the Sierra Nevada" and two on terraces of the San Francisco Peninsula and San Luis Obispo respectively, three are in economic geography and deal with avocado growing, asparagus and the eucalyptus; four are in human or historical geography on: "Early River Navigation in California," "Peoples and Economics of Nan-Shan," "History of Penetration into Southwest China," and "Settlement Geography in Southeastern United States"; one is in regional geography, the Napa Valley; and one deals with Botany of La Paz Area, Baja California.

At the University of California, Los Angeles, a candidate for the doctorate in geography is working on the San Gabriel Mountain area. Dr. Zierer states in a personal communication "We have about 15 candidates working toward the M.A. degree in Geography. Nearly all of these persons are working on theses topics dealing with aspects of the local area. We encourage the selection of local projects for M.A. candidates in order to facilitate field work."

At the University of Colorado seven master's theses are in process. Four are in economic geography: on, cantaloupes in Colorado, apples in Calhoun County, Illinois, Sugar Cane in North Kohala, Hawaii, and truck farming near Denver. One thesis is an urban analysis, one describes the Colorado—Big Thompson Diversion Project, and one is called "Nomenclature in the U.S.S.R."

X-RAYS MAY HELP SOLVE MYSTERY OF PROTEINS' ATOMIC STRUCTURE

Proteins, which include the fundamental units of which all forms of animal life are constructed, are revealed by X-ray studies to be covered with tiny spines.

Each variety of protein has its own characteristic skeleton and each skeleton carries a number of these spines on its surface. The particular sort of protein being studied is revealed by the "snowflake" pattern of its structure.

These facts about the microscopic structure of proteins were found in X-ray studies by Prof. Dorothy Wrinch of Smith College.

One of the most important unsolved problems of biology, physiology and medicine is the atomic pattern of proteins, which play a large part in the structure and functioning of living organisms. This mystery may be solved eventually by the use of X-rays, Dr. Wrinch predicted.

TEACHING EQUATIONS IN FIRST YEAR ALGEBRA

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Opportune timing is an essential factor to be considered in presenting the solution of equations to a first year algebra class. While the practices of many highly successful mathematics teachers vary widely relative to the placement of equations in the first year algebra course, the writer has found that the most appropriate time to make an effective presentation of the subject is after the students have acquired a sufficient knowledge of the fundamental algebraic processes to understand what is being done at each step of the procedure. He prefers that his students be thoroughly familiar with algebraic addition, subtraction, multiplication, division, and the handling of symbols of aggregation before they undertake the solution of equations.

When the students are ready to begin the study of equations, the first step is to arouse their interest in the topic. This is done by telling them that they have thus far in the study of algebra mainly manipulated symbols without being able to see much need for the knowledge and skills thus obtained. Now, however, they are prepared to take up what has been regarded by many recognized authorities as the most important tool in all mathematics; namely, the equation. Their attention is then called to the fact that the equation is not an entirely new thing to them. They have met it in much of the work they have thus far done in mathematics even from the first grade up to the present. When they wrote the addition facts, they used the equation in such statements as $8+5=13$; when they studied subtraction, they often wrote $9-5=4$; when they drilled on the multiplication tables, they would write $5\times9=45$; when they studied division, they would quite frequently state an exercise as $12\div3=4$; and in their later work in arithmetic, they regularly used the equation when they solved examples by the application of such formulae as $i=prt$, $A=lw$, $V=1/3bh$, and so on.

The second step is to familiarize the students with the nature and meaning of the equation. The ordinary beam balance is an excellent device for clarifying the idea. It is quite probable that every member of the class will be thoroughly acquainted with this piece of apparatus. If there is any doubt about this, however, it might be well for the teacher to describe the instrument briefly and then explain how it is used. He can illustrate the idea very vividly by balancing a pencil, pointer, or yardstick on the finger, after which he shows how any additional force applied to either end of the instrument will upset the equilibrium.

After the teacher has continued such procedure until the students have a clear conception of the nature of balance, he should then proceed to illustrations involving the weighing of objects by means of the beam balance. If this apparatus and weights are available, then the equality between various combinations of weights can be demonstrated by actual experiment. For example, let a student place a two-pound weight and a three-pound weight in the left pan and a five-pound weight in the right, and note the results. The class will see that the apparatus is in balance. Then ask the students how such a relationship could be expressed mathematically. They will readily respond that one could state this relationship by writing the symbols, $2+3=5$. Now point out to the students that this is an equation, and then follow with several other combinations to further clarify the idea. Next ask the students to state the relationship existing between the total weight in one pan and that in the other when a balance exists. Without hesitancy they will say that these weights are equal. Here point out to the students that the mathematical symbols which have been put together to show the relationship between the weights in the two pans when the instrument is in balance, make up what is known in mathematics as the equation.

At this stage in the development of the idea, the teacher might ask the students to define an equation in terms of what they have thus far experienced. A surprisingly large number will say that an equation is an expression of balance between two quantities, or will give a statement having a similar meaning. Here is the place to emphasize the fact that just so long as two quantities are balanced, the relationship can be expressed by means of the equality sign, and the resulting statement is an equation. However, when the balance ceases to exist, the equality no longer exists, and no longer can the equality sign be used to express the relationship after the balance has been destroyed. Hence, any process which would upset the balance must be avoided when operating upon an equation.

The third step in teaching the solution of equations is to show the students how to perform operations on both members of the equation without destroying the balance, and to continue the process until the root has been found. For this part of the presentation the writer likes to make the approach through the use of diagrams of beam balances sketched on the blackboard. Assume that some item is being purchased by weight at the local store, and by means of the diagrams, set up situations to illustrate equations whose solutions require the various operations ordinarily used. For the first example, suppose that a person wishes to buy 10 pounds of sugar. The clerk will place a 10-pound weight in the right balance pan, and then fill a sack of sugar and place in the left. He finds that the sugar is too heavy, but by

pouring 2 pounds out of the sack, the sugar now just balances the 10-pound weight. How many pounds of sugar were in the sack at first?

At this point, the teacher can, by a few well chosen questions, get the students to make a word statement describing the relationship between the original amount of sugar and the weights. They will probably say, "The amount of sugar in the sack at first less two pounds equals ten pounds." Now ask them to express the word statement in mathematical symbols, letting s represent the sugar. The teacher will have little difficulty in getting some student to write on the board such a statement as, $s-2=10$. Again emphasize the fact that these symbols represent the instrument when it is in balance, and they, therefore, make up an equation. Here point out that an equation is solved when it has been operated upon in such a manner that the unknown (in this case s) stands alone on one side of the equality sign with a numerical coefficient of positive one, and the knowns appear on the opposite side, simplified as much as possible. It is here suggested that the word "member" be used to describe that part of an equation on one side of the equality sign, and that the left and right members represent the weights in the left and right balance pans respectively when equilibrium exists.

To lead the class to understand how the equation, $s-2=10$, is solved, the teacher might proceed as follows:

Teacher: In what member is the unknown?
Student: In the left.
Teacher: Is the unknown alone in the left member?
Student: No. The -2 is also in that member.
Teacher: What could be done to this member to make the -2 disappear?
Student: Add 2 to the -2.
Teacher: Would a balance still remain?
Student: No.
Teacher: How could the balance be restored?
Student: Add a 2 to the right member also.
Teacher: What now would be the value of the right member?
Student: 12.
Teacher: Then what is the value of s?
Student: The s would equal 12.
Teacher: Then this equation has been solved by adding the same thing (a positive 2) to both members.

For the second example, suppose the grocer puts a 10-pound weight on the right pan and a sack of sugar on the left, and finds that the weight is too heavy to balance the sugar. He then puts a 2-pound

weight on the left pan with the sugar and finds that a balance again exists. How much does the sugar now weigh? Again get a student to write on the board the equation which represents this relationship, or $s+2=10$. By means of questions similar to those used in solving the first example, the fact is brought out that this equation is solved by subtracting the same thing from both sides.

For the third example, suppose the clerk puts a 10-pound weight in the right pan and a sack of sugar in the left, and finds that the sugar is too heavy. He then pours out one-half the sugar and discovers that equilibrium again results. How much sugar was in the sack at first? Some student will now express the relationship by writing the equation, $1/2\ s=10$. The following steps might be taken in the solution:

Teacher: What is the coefficient of s in the equation?
Student: One-half.
Teacher: What will be the coefficient of s when the equation has been solved?
Student: Positive one.
Teacher: How could the $1/2\ s$ be operated upon in order to make its coefficient positive one?
Student: Add $1/2\ s$ to both members. (This is the answer most frequently received at first.)
Teacher: This would give sugar in the right balance pan also, which should be represented by another $1/2\ s$, and would cause the unknown to appear now in both members. What other procedure might one use to make an s from $1/2\ s$, other than add $1/2\ s$ to both members?
Student: Multiply both sides of the equation by 2.
Teacher: What would then be found for the value of s?
Student: The s would equal 20.
Teacher: This equation has been solved by multiplying both members by the same quantity, which was a 2 in this case.

In the fourth example, suppose that three sacks, respectively containing equal amounts of sugar, are on the left pan and are balanced by a 12-pound weight on the right. How many pounds of sugar in each sack? Again have a student represent the relationship by writing the equation, $3s=12$. Now the teacher asks what may be done to the left member to have only an s remaining. Here he is likely to receive the reply that $2s$ should be subtracted from the left member. If so, call attention to the fact that $2s$ must then be subtracted from the right member, thus causing unknowns to appear in both members, thus resulting in an equation more complicated than the original one. If the students fail to see any other method of attack, the teacher

might ask a student to find the cost of one pencil, if 3 pencils cost 12 cents. The method used in obtaining this answer is obvious, and can be carried over to finding the value of s when $3s=12$. Now the students will conclude that this equation has been solved by dividing both members by the same quantity.

After the class has solved a few examples each of which requires only one operation, it is then time to introduce an equation whose solution involves more than one, or even all four operations. For example, let it be required to solve the equation, $5x+12=28-3x$. It has been the writer's observation that students will understand the process better and retain the knowledge longer, if they are required at first to write out or give oral explanations for each step taken in the solution of the equation. He finds that the following form for a written explanation works quite well:

	$5x+12=28-3x$	(1)
Subtract 12 from both members of (1):	$5x=16-3x$	(2)
Add $3x$ to both members of (2):	$8x=16$	(3)
Divide both members of (3) by 8:	$x=2$	(4)
Check—Substitute 2 for x in (1):	$5(2)+12=28-3(2)$	
	$10+12=28-6$	
	$22=22$	

After the students have had considerable practice in solving examples similar to the one above, it is then time for the teacher to call their attention to the fact that they have been actually using well-known principles, called *axioms*, in solving these equations. At this stage in the development, the teacher might profitably spend some time in discussing the nature of an axiom, and in getting the class to state and illustrate the four axioms commonly used in solving equations. As soon as the students have acquired this information, they should then be given an opportunity to solve many more equations, stating the axiom used in each operation.

The meaning of the term "root" and the principle of checking should be brought to the attention of the students as they are learning to solve equations. It should be made very clear to them that the only way by which they know that the value obtained for the unknown is correct, is to see if this value, when substituted for the unknown, will produce a balance. The only way to determine whether or not such a balance exists is to see if both members of the equation will become identical quantities when the value thus found has been substituted for the unknown in the original equation. Here it should be strongly emphasized that a substitution in any equation other than the given one is not sufficient to detect an error made at any step preceding the equation in which the substitution is made.

The fourth step to be taken in teaching the solution of equations is to introduce the process of transposition. While many excellent teachers of mathematics strongly oppose the teaching of transposition to first year algebra students, the writer feels that the students will save considerable time and effort in subsequent courses in mathematics, if they have learned how to utilize transposition in solving equations. Transposition, however, should not be used until the students have had sufficient drill in solving equations through the use of axioms to understand that the process of transposing is only a mechanical way to apply the addition and subtraction axioms. In order to get the student to appreciate the connection between the process of transposition and these axioms, the teacher might solve an example similar to the following:

$$2x+4=24-2x. \tag{1}$$

To remove 4 from the left member of (1), subtract 4 from both members, but indicate the subtraction rather than actually perform the process. The resulting equation will then be

$$3x+4-4=24-4-2x. \tag{2}$$

By combining the positive 4 and negative 4 in the left member of (2), the equation will then take the form

$$3x=24-4-2x. \tag{3}$$

To remove the negative $2x$ from the right member of (3), add $2x$ to both members, but again just indicate the addition rather than actually combining the terms. The equation now becomes

$$3x+2x=24-4-2x+2x. \tag{4}$$

Now combine the positive $2x$ and the negative $2x$ in the right member of (4), and the resulting equation is

$$3x+2x=24-4. \tag{5}$$

By comparing equation (5) with equation (1), it will be seen that the application of the subtraction axiom to equation (1) caused the positive 4 to disappear from the left member of this equation and a negative 4 to appear in the right member of equation (5). Furthermore, the addition axiom applied to equation (1) caused a negative $2x$ to drop out of the right member and at the same time a positive $2x$ to appear in the left member of equation (5). From this and similar examples, the class will readily conclude that a term may be moved from one member of an equation to the other by changing the sign of the term so moved.

After the students have discovered why the sign changes when

the term has been moved from one member to the other, they should then be encouraged to use transposition thereafter in the solution of equations, and thus save time and effort often expended in the application of the addition and subtraction axioms. In this connection, however, the students should be thoroughly cautioned to the effect that transposition includes the moving of a whole term, not just a part of a term, and that this movement must go across the equality sign, and not from one position in a given member to another position in the same member. It should also be emphasized that transposition should not be used when factors are to be removed from a term.

Even though students are permitted to solve equations by transposition, the writer finds it advisable to require them to learn how to write out the steps thus taken in order to fix the process well in mind. A convenient form is given below:

	$5(3x-2)-8x=7-(x-15)$	(1)
Performing indicated operation in (1):	$15x-10-8x=7-x+15$	(2)
Transposing in (2):	$15x-8x+x=7+15+10$	(3)
Collecting terms in (3):	$8x=32$	(4)
Dividing both members of (4) by 8:	$x=4$	(5)
Check—Substitute 4 for x in (1):	$5[3(4)-2]-8(4)=7-(4-15)$	
	$50-32=18$	
	$18=18$	

The preceding discussion has been intentionally limited to a treatment of the solution of integral equations of the first degree in one unknown. The writer feels, however, that students well-grounded in the principles involving the solution of this type of equations, will have very little difficulty in learning how to carry these principles over the solution of more complicated forms of equations as the needs arise.

NEW SUPERSONIC WINDTUNNEL HAS ENCLOSED AIRSTREAM SYSTEM

An enclosed airstream system which cleans and dries air for reuse has been installed in a small windtunnel at the University of Washington Aeronautical Laboratory.

In a tiny opening of two square inches, flying conditions at an altitude of 80,000 feet with a speed of 1,360 miles per hour are simulated. Modifications may give conditions up to an altitude of 200,000 feet at 2,000 miles per hour.

By using the enclosed airstream, it is not necessary to continually remove moisture from outside air.

Although the actual test section is small, the complete unit, powered by four large vacuum pumps, is 20 feet long and four feet high.

THE LUNAR ATMOSPHERE

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Telescopic observation of the moon supplies conclusive evidence that the earth's satellite has practically no atmosphere. If there is any at all, it probably exerts a barometric pressure less than 1/100,000 of the atmospheric pressure at the earth's surface. Thus, there is no perceptible haze, and all shadows are perfectly black. There is no evidence of clouds, storms, or other meteorological phenomena. Occultations of stars supply further evidence. The star retains its full brightness in the field of the telescope, until, without warning, it disappears. Its reappearance is even more startling. If the moon had a perceptible atmosphere, or the star a sensible diameter, the effects would be more gradual. The star image would change color, become distorted, and gradually fade away.

Astronomers are agreed on the hypothesis that the moon at one time formed a part of the earth, and consequently possessed an atmosphere. The retention of the atmosphere by the earth, and not by the moon, can be explained in terms of variation of the volume of a sphere with changes in its radius. The volume of a sphere varies directly as the cube of its radius ($V = \frac{4}{3}\pi r^3$). If the sphere is homogeneous, its mass and, therefore, its gravitational attraction would also vary as the cube of its radius. At any given distance from a spherical body there is a velocity of escape, or parabolic velocity, which depends on the mass of the body. [The formula used in computing the velocity of escape is $U^2 = 2G(\frac{M+m}{r})$, when U is the parabolic velocity, G the constant of gravitation, M the mass of the earth, r its radius and m the mass of the moving particle, which, of course, can be neglected.]

Substituting the known values for the earth and moon, gives $U = 11.3$ km./sec. for the earth, and $U = 2.4$ km./sec. for the moon.

According to the kinetic theory of gases, the mean-square velocity of molecules (i.e., the velocity whose square is equal to the mean of the squares of the individual velocities) varies inversely as the square root of the molecular weight of the gas, and directly as the square root of the absolute temperature. The value of this velocity at 0°C. is 1.8 km./sec. for hydrogen, 1.3 for helium, 0.6 for water vapor, 0.5 for nitrogen and oxygen, and 0.4 for carbon dioxide. At 100°C., these velocities would increase by about 17%.

There will be considerable escape of molecules, even though the mean velocity of the molecules is less than the parabolic velocity, since fast moving particles, in the upper regions of the atmosphere, where the free paths of molecules are relatively long, stand a good chance of escaping before being stopped by collisions. Jeans has calculated that, if the mean molecular velocity is one-third the velocity of escape, the atmosphere will be reduced to one-half its original amount in a few weeks.

Thus, it follows that the earth should be able to retain all known gases for a practically indefinite period. Hydrogen and helium should diffuse from the moon very rapidly. Water vapor should diffuse more slowly, but, geologically speaking, in a short time. At 100°C., oxygen and nitrogen should slowly, but steadily, escape. If ever in its history the moon were really hot, it must have lost its heavier gases as well.

Chimney mounting for radio antenna is an eight-inch square cadmium-steel plate with two standoff clamps, perforated steel straps and turnbuckles. The plate is placed against a corner of the chimney. The steel straps passed around the brickwork are tightened by the turnbuckles without the use of other tools.

MAKING THE MOST OF ASTRONOMY IN HIGH SCHOOL SCIENCE*

R. WILLIAM SHAW

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Astronomy, as it is taught today in the great majority of secondary schools, appears in the curriculum as a unit in general science and not as a separate discipline as does physics, chemistry or biology. The authors of the leading general science texts devote from four to twelve per cent of their volumes to astronomical topics. It is interesting to note, incidentally, that the more voluminous texts are not in general those in which most space is devoted to astronomy. In almost every text, and rightly so, considerable attention is given to the solar system. Topics such as latitude, longitude, time, seasons, eclipses and the tides are treated with unexpected detail. On the other hand, very little attention is given to the properties of the stars, to the Milky Way or our Galactic System, or to the External Galactic Systems and the Universe as a whole, and yet it is in these areas that much of our current research is being done. Also it appears difficult to understand why so little attention is given to the great instruments of astronomical research such as the spectrograph and the giant telescope.

It has not always been the practise to teach astronomy as part of a general science course. The text, *Astronomy for Use in Schools and Academies*, was used in 1882 for a semester course on a par with physics and chemistry. The authors, Gillet and Rolfe, state in their preface "that there is nothing in the book beyond the comprehension of the pupil of the ordinary high school or academy, and that it contains all the information on the subject of astronomy that is needful to the person of ordinary culture." It is notable that this text placed considerable emphasis on the techniques of obtaining astronomical knowledge and the reader is made keenly aware of the methods by which he makes contacts with the universe. It is the present writer's opinion that the student must have some first hand contacts with the phenomena of science if he is to appreciate clearly that science is primarily a method of correlating our experiences with the physical universe.

It is not our intention to elaborate on the relative merits of teaching astronomy as a separate science or as a part of a general science, but rather to probe the possibilities of making the most of astronomy in high school science from the standpoint of bringing the student into actual contact with some of the fundamental phenomena.

* Lecture and demonstration delivered before the New York State Science Teachers Association at Cornell University on July 2, 1948. A visit to the Fuertes Observatory followed the lecture and demonstration.

Of the many characteristics of astronomical science which make it worthy of attention in any educational program, two will be emphasized here. In the first place astronomy is an observational science. It is not an experimental science in the same sense as physics or chemistry. There is nothing we can do to alter or control the movements or properties of the celestial objects. We must observe the phenomena, simple or complex as the case may be, when the opportunity presents itself. From the student viewpoint this is, perhaps, a fortunate circumstance. Ability to plan experiments of value requires considerable training, and, obviously, can hardly be expected of a beginner. Moreover, it is perhaps not even desirable to attempt to develop the ability in individuals not destined for scientific work. The first requirement in astronomy is the ability to observe and report accurately the phenomena as they are presented. And who will deny the importance of this ability in any walk of modern life?

The second characteristic of astronomy which we shall emphasize is the ease with which any individual can maintain contact with the science as a hobby. The phenomena are always readily available for observation. Interesting changes are constantly taking place, and the observational equipment may range from one's own eyes to the most elaborate of observatories.

With these two characteristics of astronomy in mind let us examine some of the activities in participation of which the student will gain a deeper understanding of the universe about him.

Learning to Identify the Stars

Little progress can be made in observational astronomy without some knowledge of the identity of at least a few of the bright stars, but the acquisition of this knowledge need not be the hurdle which it appears to be in the eyes of many persons. In the first place one need be able to identify only a comparatively few stars. The ability to use intelligently a star chart for general identification purposes is more to be desired than uncertain reliance on the memory.

For the accurate and rapid identification of bright stars the Millar Observoscope will be found especially useful. This little device, when properly oriented, will point to the momentary position of any bright star either above or below the horizon. If this instrument is available, it might be loaned to individual students for home work in developing a knowledge of the stars. A somewhat simpler star finder, which can be very easily constructed of wood, is described in the *Handbook of Nature Study* by Comstock (University Press, Cornell University, Ithaca, N. Y.). These aids tend to develop confidence in making identifications, and their use is especially recommended for persons working alone.

In a large class the teacher will usually find a few students who have some knowledge of the stars as a result of scout training or similar activity. A preliminary session with these students, a star chart and the sky will develop rapidly squad leaders who will assist later in training the bulk of the class. Teachers not too familiar with the stars will find it advisable, before enlisting aid in stellar identification, to determine exactly which stars and constellations are to be expected at a given time. Monthly star charts such as those published in *Sky and Telescope Magazine* (Harvard College Observatory, Cambridge, Mass.) are admirable for this purpose. Early evening hours in fall and spring are best for general class work. Several short meetings are more beneficial than one long session.

Excellent star charts, both hand and wall, can be purchased from Rand, McNally and Company and from Denoyer-Geppert Company. The latter company handles Norton's *Star Atlas*, an English work, which is undoubtedly the best star atlas available for amateur use. It contains a wealth of interesting material and no serious student of astronomy should be without it.

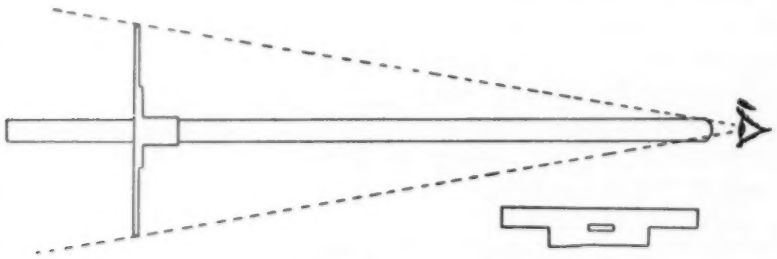

FIG. 1. Cross-staff and Transversal

POSITIONS OF THE PLANETS AND THE MOON

As soon as the student is able to identify a few of the bright stars he is ready for observations of the movements of the Planets and the Moon. Information concerning the planets visible each month is printed in *Sky and Telescope Magazine*. *The Graphic Time Table of the Heavens* published by the Maryland Academy of Sciences (Baltimore, Maryland) for free distribution is a valuable aid in determining when to look for the more conspicuous celestial objects.

The angular distance of one celestial object from another is easily obtained by a cross-staff (See Fig. 1). A cross-staff consists of an ordinary meter bar on which slides a wood or metal transversal shaped in the manner shown at the lower right in the figure. The long portion is 20 centimeters in length, the short 10 centimeters, and the over-all width is 5 centimeters.

To operate the instrument hold the zero end of the bar close to the eye and direct the bar to a point about half way between the two objects whose angular separation is desired. Slide the transversal along the bar until the desired objects appear exactly at the ends of the transversal. The two lines of sight are represented by the dotted lines of Fig. 1. The angle is computed from the tangent of half the subtended angle. For small angles the short portion or the width of the transversal is used. To properly locate an object measurements should be made from three stars. The time of observation should be noted.

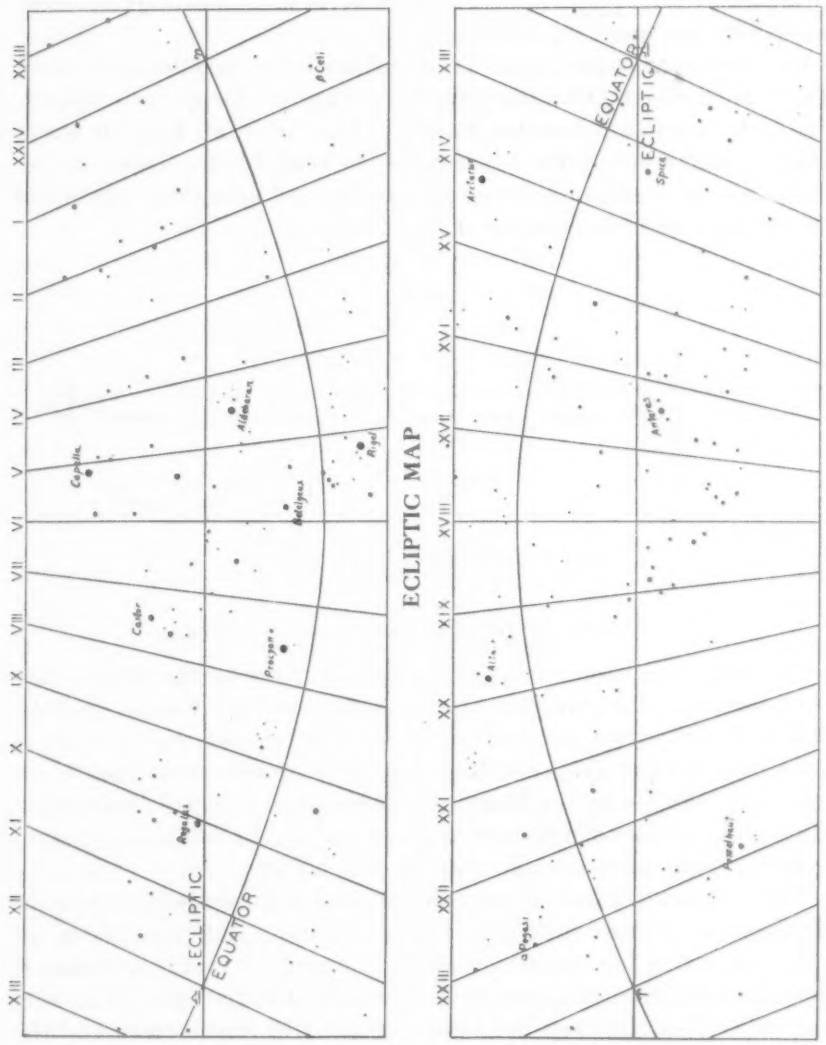

FIG. 2

To maintain a record of the movements of the planets or moon among the stars an ecliptic chart similar to that in Fig. 2 will be necessary. It is suggested that a wall chart copied from this figure be prepared. It will be convenient to represent one degree by one-half centimeter. This means that the distance on the ecliptic (Sun's path) from the vernal equinox (♈) to the autumnal equinox (♎) will be ninety centimeters. The remainder of the chart should be laid off in proportion. The unlabeled stars may be identified from any star chart. More elaborate ecliptic charts, as well as detailed accounts of many interesting astronomical exercises, will be found in *Manual of Astronomy* by Shaw and Boothroyd (Appleton-Century-Croft, New York City).

To plot the position of an object proceed as follows. Adjust the legs of a pencil compass to a distance in half centimeters equal to the angle measured by the cross-staff. Place one leg of the compass on the reference star and describe a circle. Repeat for the angles measured from the other stars. The common intersection of all circles is planet's position. Label with the date and time of the observation.

Observations of this kind can just as well be made at home, if the student is fairly familiar with his stars. Similar observations by several students on the same night will reduce to a minimum the possibility of confusion arising from a possible mis-identification of a star. If the observations are continued for some time, both forward and retrograde motions of the planets will be observed. The interpretation of the observed motions in terms of the Copernican theory will serve as an excellent class discussion problem. If lunar observations are continued for some months, evidence for regression of the lunar orbit will be discovered.

Observing with a Telescope

For the observation of the physical features of the Sun, Moon, or Planets we must have some telescopic aid, but it need not be elaborate. The author has constructed a creditable telescope from a three-inch reading glass and an eyepiece borrowed from a microscope, the whole mounted with rods and clamps on a laboratory tripod. Almost every community boasts of at least one amateur telescope maker who is usually delighted to show the wonders of the heavens.

A very helpful device for the study of the Moon, and a necessity for the Sun, is the telescopic projection screen shown in Fig. 3. The device is simple to construct and permits simultaneous observation by a number of students as well as the preparation of accurate drawings. Preparation of a series of Moon maps representing the different phases, embellished with as much detail as possible, will be effective in stimulating interest in our nearest neighbor. Construction of a se-

ries of solar drawings showing the location and change in sun-spots from day-to-day is an excellent daytime project. It will be interesting to determine the sizes of the spots in terms of the size of the sun. A graph of spot numbers against time makes a curve, which, if carried on from year to year, will stimulate all kinds of correlations with terrestrial affairs. On clear days the projected images can be made quite large and fine details of the spots are easily observed.

Jupiter, Saturn and Venus are the best planets for beginners to observe. Drawings are always desirable, colored in the case of Jupiter. Movement of Jupiter's satellites can be detected by watching closely for a few minutes. Rings of Saturn and phases of Venus (with class interpretation) are specially interesting.

While we are doubtless justified in devoting most of our time to the astronomy of the solar system in general science, it is nevertheless

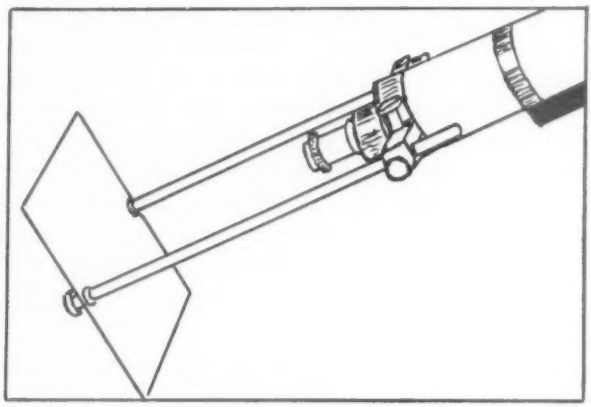

FIG. 3. A simple projection screen for use with a telescope or large binoculars.

desirable that our students experience some slight contact with the greater entities of the Universe. This is especially true for those students who will have no further opportunity to pursue the subject. We must content ourselves, however, with selecting a few typical objects from the almost limitless number. Mindful of instrumental limitations we select only objects which can be observed satisfactorily with binoculars. Student reports on these objects would be desirable.

1. The Milky Way. The dark rifts are obscuring clouds of dust in interstellar space. Fall and spring observation.
2. Excellent examples of Galactic Clusters are the Double Cluster in Perseus and the Pleiades. Fall observation.
3. Luminous diffuse matter can be seen around some of the Pleiades Stars and gorgeously as the diffuse nebula of Orion. Fall and winter observation.
4. The Globular Cluster in Hercules (Messier 13) is visible to the unaided eye even though it is distant 33,000 light years. Fall and spring observation.

5. Double stars are numerous. Beautiful examples are Beta Cygni (blue and gold), Gamma Andromedae (blue and gold), and Epsilon Lyrae, the Double-double. Analysis of the motion of double stars forms the basis for the assumption that Newton's Law of Gravitation is valid outside the Solar System.

6. The Andromeda Nebula (Messier 31) is an external galaxy distant about 800,000 light years. Fall observation.

Latitude and Longitude

The concepts of Latitude and Longitude are frequently very difficult for students to grasp. Much of the difficulty arises from the total lack of actual contact with the celestial observations on which these entities are based. A few simple experiments with a plane table and gnomon (See Fig. 4) will dispel most of the difficulty. This device consists of a board about 18 inches long and 8 inches wide on which is erected an upright post, the gnomon, which may be from 2 to 5 inches in height. The gnomon must be accurately perpendicular to the board, and the board should be provided with screws for leveling. A sheet of paper on which the observations are recorded is tacked to the top of the board. The observational procedure involves only the

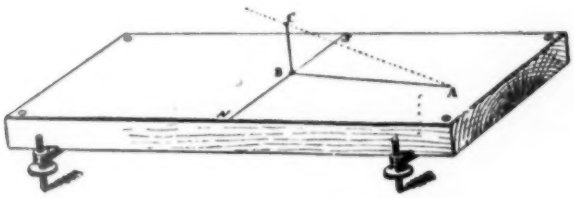

Fig. 4. Plane Table and Gnomon.

marking with a pencil dot the position of the end of the gnomon shadow, as cast by the Sun, at frequent intervals throughout the day. The exact time of observation should be noted. The angle CAB is the momentary altitude of the Sun. Fig. 5 shows a plot of solar altitudes made at ten minute intervals at Ithaca, N. Y. The time of maximum altitude is the time when the Sun crossed the observer's meridian. In the figure this time is clearly not the watch time of noon. Moreover the interval between watch noon and meridian noon is not one hour. The difference arises from the facts that Ithaca is six minutes west of the standard meridian and the equation of time for the day was about seven minutes. Time of meridian transit is determined by this method with an accuracy of about two or three minutes.

If we can arrange with members of a class in another city (our example; Duluth, Minn.) to make a similar set of observations, we obtain directly the difference in longitude of the two places as the difference in times of meridian transit of the Sun. This simple experiment relates longitude directly to time and the rotation of the Earth.

Latitude is determined from the maximum altitude by the formula: Latitude = 90°—(Altitude—Dec. of Sun). On or about September 22 and March 21 the Sun's declination is zero and the latitude is the complement of the altitude.

If one is fortunate enough to possess a surveyor's transit or sextant, the accuracy of the observations can be significantly increased, but no advantage accrues in the demonstration of the principles involved. A series of sun altitude curves obtained at different times in the year will emphasize for the student the meaning of the seasons in a manner never to be forgotten.

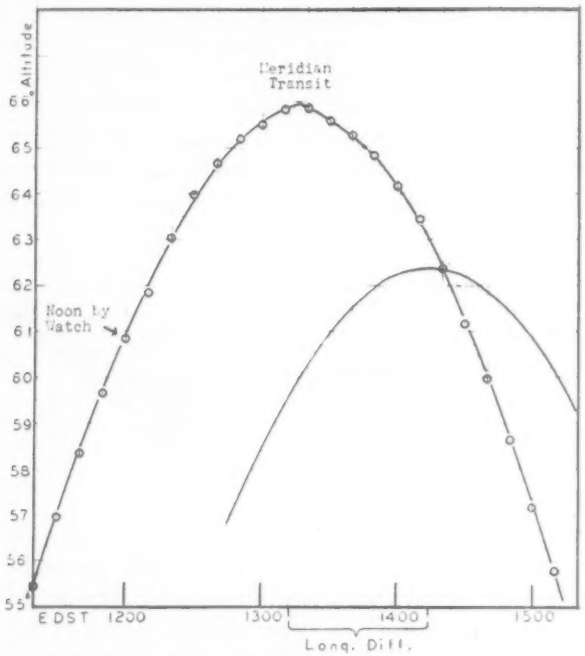

FIG. 5. Sun altitude curves at Ithaca, N.Y. (dash curve) and at Duluth, Minn. (smooth curve). All times are Eastern Daylight Saving Time.

OBSERVING A VARIABLE STAR

For our final project we turn to the stars. The object Beta Persei, or Algol as it is popularly known, consists of two stars, one dark and the other bright, which mutually eclipse one another as they move about a common center of gravity. The change in brightness resulting from the eclipse of the bright star by the dark component is so pronounced that it is easily observed with the unaided eyes. Moreover, since the eclipse takes place every 2-days and 21-hours, opportunities for observation occur frequently. Beta Persei is in an excellent position in the northern sky for fall and winter observation. Predicted

times of eclipse are published monthly in *Sky and Telescope Magazine*.

The relative brightness of a star is expressed in terms of an arbitrary scale of magnitudes. The fainter the star the larger the magnitude number assigned to it. Sixth magnitude stars are the faintest stars which can ordinarily be observed with the unaided eyes. The determination of the magnitude of Algol at a known time of observation constitutes our entire observational problem. The following stars will serve as standards of magnitude.

Star	Magnitude	Difference
Alpha Persei	1.9	
Gamma Andromedae	2.2	0.3
Beta Andromedae	2.4	0.2
Zeta Persei	2.9	0.5
Gamma Persei	3.1	0.2
Alpha Trianguli	3.6	0.5
Tau Persei	4.1	0.5

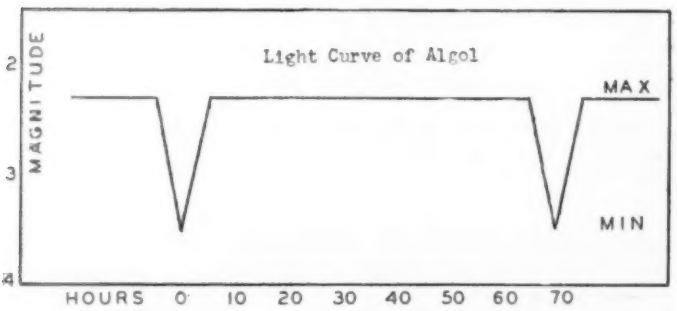

FIG. 6. Light Curve of Beta Persei. A small decrease in brightness can be observed halfway between the major minina by means of a sensitive photoelectric cell. This means that the dark companion in the system is not completely black.

Algol is compared for brightness with each star on the list. Since the human eye is a remarkably sensitive judge of small differences in brightness, it will not be difficult to determine which star is just slightly brighter than Algol and which is slightly fainter. The magnitude of Algol is then estimated in terms of these two stars.

The form of the Light Curve of Algol is shown in Fig. 6. The observational program consists of constructing a similar curve from original observations. A large wall chart on which all observations can be entered will excite considerable interest. From the figure it will be noted that the system grows fainter for a period of about five hours and then suddenly grows brighter for an equal period. This allows ample time for each student to make several observations during a minimum of brightness. After the technique has been well established, the work can be carried out at the student's home. Number and

quality of observations reported will serve as the basis for a competitive grade.

In our choice of projects with which to bring the student of general science close to the phenomena of astronomy, we have emphasized activities which are uncluttered by complicated and expensive equipment, activities which can be carried out at least in part at the student's home, and activities which emphasize the ceaseless change which goes on in the Universe. Finally every activity, with the possible exception of star identification, and every object we have mentioned are the subjects of more refined study and investigation by astronomers at the present time. The student should not feel that he is merely redoing "old stuff," but rather that he is beginning a study of things only partially understood and the investigation of which might well occupy a life time of effort.

SLIDEFILMS FOR TEACHING NATURAL SCIENCE

LYNE S. METCALFE
51 East 42nd Street, New York 17, New York

A long-awaited series of discussional-type slidefilms for teaching under water life and for study has been added to its "Science Adventures" series by The Jam Handy Organization.

This is a fiddler crab. One claw is much larger than the other and looks like a violin, or "fiddle". The crab waves its large claw in the air as it walks.

This series of films is titled, "Water Life," and comprises seven slidefilms all in natural color and with labels, letterings and explanatory text for the guidance of instructors and for the benefit of the study group in schools or elsewhere.

While primarily designed to be used for science classes, grades 4, 5, 6, 7 and 8

oral reading classes, grades 4, 5 and 6 biology classes, grades in junior and senior high schools, these films also lend themselves to showings before interested groups in outdoor subjects, the fishing fraternity and other small groups studies.

The seven color films are organized into 24 topics as follows: 1. Life in Ponds, Lakes and Streams; 2. Small Fresh-water Animals and Insects; 3. Fresh-water Shellfish and Amphibians; 4. Fresh-water Turtles and Fish; 5. Keeping an Aquarium; 6. Plants and Strange Animals of the Sea; 7. Shellfish of the Seashore.

Feeler
Eye
Mouth
Foot
A snail goes about on a single foot. Its mouth is in the front part of its foot. It has two eyes and two feelers. *Land* snails have *four* feelers.

ATOMIC AGE SMOKE "SIGNALS" SENT FROM WEATHER TOWER

First atomic age smoke signals have been sent from the giant weather tower at the Brookhaven National Laboratory.

The smoke "signals," formed by a harmless fog, are used to trace the speed and course of wind over the laboratory. This study will permit sending off harmlessly into the air waste radioactive gas from a new atomic pile when it is completed.

Smoke from the 355-foot tower is photographed by weather observers in mobile stations. The fog behaves in the air in the same way the radioactive gases will.

NEW URANIUM MINERAL FOUND IN BELGIAN CONGO

A new radioactive mineral containing the atomic bomb element, uranium, has been discovered in the Belgian Congo.

Laboratory tests by Dr. Kerr showed that the material is a previously unknown uranium mineral. It has been named "sengierite," in honor of Edward Sengier, who directed wartime mineral production in the Belgian Congo.

Sengierite is found in small green crystals which cling to a chlorite-talc rock found in mines in the Belgian Congo. It is similar to the American uranium mineral, carnotite, except that sengierite is a copper uranium mineral, while carnotite is a potassium uranium material.

SOME TECHNIQUES IN THE TEACHING OF GRADE SCIENCE AND ITS APPLICATION TO SECONDARY SCHOOL SCIENCE*

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AND
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If what educators say is true—that we have in our elementary classroom both tomorrow's layman and tomorrow's scientist, that we can no longer afford to neglect the needs of all the people in our democracy, that people's needs are dependent to a great extent upon science—then we must have a continuous program of science instruction throughout public school education from kindergarten to grade 12 to fulfill these goals.

And yet, in many school systems, little or no science teaching is included below the seventh grade. Two surveys conducted last year. one to superintendents and the other to elementary principals in the state of New York, indicated that the administrators wanted, by a large majority, elementary science as a part of the elementary school program. Probably one of the reasons that grade science is not included in many of our elementary schools is that classroom teachers are hesitant about teaching science. This may be due to the fact that they have little or no training in science. Yet, there is evidence that many classroom teachers have become successful teachers of grade science with little or no science training. One could deduce that this hesitation by classroom teachers is due to one or more of the following causes:

1. They think that they must be prepared to answer all the science questions asked by children.
2. They do not know where to begin in the teaching of science.
3. They are not familiar with setting up simple experiments.
4. They think that science teaching has a unique procedure differing from other subject matter fields.

It is this latter phase that we wish to discuss. Let us examine briefly what the teacher does in the accepted subject matter fields. In arithmetic she knows that certain areas of work must be covered in the various grade levels. She has a text or a work book and follows it rather religiously. In reading, she knows what to emphasize either

* An address delivered to the New York State Science Teachers Association at the New York State School of Agriculture and Technology at Farmingdale on April 24, 1948.

in the primary or intermediate level. A text is her guide. In social studies she has a flexible pattern of work to follow with a text. The same holds true for language. In all of these fields the teacher feels quite confident to cope with most situations. And in all of the fields of work mentioned, the children do use supplementary books, take field excursions, learn to read maps, learn to manipulate the globe, write for materials, etc. And whenever children bring up questions or problems in these fields, the teacher does not hesitate to guide the children in seeking the solutions. Yet, the teaching of grade science frightens most classroom teachers because they do not realize that the very same methods and techniques used in social studies, reading, etc., are directly applicable to the teaching of grade science.

What are some of these techniques that we use in the teaching of grade science?

I. Using Children's Questions About Their Environment

To the teacher comes the child filled with questions about his world. Why is the sky blue? Do birds stay out in the rain and get wet? Did you know that you can see electricity? It leaks out of a dry cell battery. Why is the sunset red? These and many others are thrown at elementary teachers every day. Many teachers ignore them; others brush them off with a vague answer. Alert teachers use them as vehicles for stimulating science.

Let us see how the question about birds would be handled by the teacher. The teacher would start discussion. The discussion might center around feathers, serving as an umbrella, being close together as shingles on a house, suggesting that maybe the feathers had something on them that kept out the rain. Probably the next approach would be to ask, "How do we find out?" At this point, the children may either visit the library or secure help from outsiders, for information. Possibly in all of this process, someone might mention that oil and water do not mix and that maybe the feathers had something like oil that caused the rain to run off. At this point, the teacher may suggest that they ask the custodian for some oil and put some on a piece of paper and pour water on this paper. From this simple experiment the children can draw a conclusion to answer their original question. Questions about the environment originating with the children lead to interesting and challenging experiences.

II. Establishing Science Interest Table in the Classroom

Probably no one technique in arousing interest and stimulating natural curiosity is as valuable as the inclusion of the science interest table. This table can exhibit materials prior to the start of an area of work, such as collections of seeds, rocks, or sea shells, or materials

children can manipulate, such as push buttons, bells, toy magnets, etc. This table encourages the children to bring in materials from their environment. Other children handle these and become acquainted with them. It is the well from which the teacher can draw problems as well as a stimulus to a planned unit or an outgrowth of a study already in progress.

III. Using Firsthand Materials—Simple Experimentation

Children have toys with a scientific slant in these days: magnets, periscopes, chemistry sets, flashlights and many others which are often brought to school. These lead to simple experimentation. Let us see how a typical experiment would be worked out. A child may bring up this question—"Where does the sun go when it goes down?" Methods are discussed as to ways to solve the problem. At this point the children play the role. They suggest reading. In the reading an experiment is found. The children read about the experiment and, together with the teacher, plan how they would do the experiment. These are written either on a board or chart. The problem of getting materials is discussed. What shall we use for the earth? What shall we use for the sun? Probably a globe is suggested as the earth. Maybe an electric lamp is suggested as the sun. A group does the experiment and the results are thoroughly discussed.

The experiment carried out in this manner does not become a demonstration in which the problem, the procedure, and the conclusion is established by the teacher. Rather, the solution is established by the children through participation in the whole process. In a similar manner, other firsthand materials that lend themselves to the experimentation could be utilized.

IV. Identification

Identification of objects, e.g. rocks, birds, soil, insects, could be considered as another technique. Let us illustrate how it could be carried out in grade science.

Various companies and organizations have pictures of birds, flowers, animals, etc. One flour company inserts pictures of birds in its cereal packages. Let us assume that a picture of a bird was brought to the classroom. A science situation is set up when the group discusses the picture. The discussion may lead to What bird is it? What does it eat? Where does it live? These are problems that the class would like to solve. Possibly from the library, or from the files of a secondary school science teacher, a scale size drawing of that bird may be obtained. From this picture the children could study coloration, as well as read about the habits of the bird. The children could be guided to observe other birds and record them on a chart. Possibly

their reading and discussion would lead them to further study of bird life—their economic value to us, building of bird houses, feeding stations, and perhaps taking field trips to observe bird life. Thus from an object lesson, identification served as a means to an end.

V. Group Planning

Another technique is group planning in an area of work. Children bring things to the class. Possibly a praying mantis egg mass. From study of this egg mass a discussion arises as to the value of the praying mantis. This might lead the class to the area of conservation. With the teacher the discussion could center around themselves as well as their community. Some of these problems may arise: plant and animal life, harbor pollution affecting their swimming, their own health, farm lands, and so on. The problems are developed from these main areas and are always closely related to the experiences of the child. Reading is carried on throughout the study. The problems are broken up and selected by the groups for solution. The groups plan the solution to their problems. Some specific techniques may be:

1. field trips
2. interviews
3. taking pictures
4. writing for materials
5. reading
6. experimentation

The solution to the problem must be of interest to all. Therefore, various activities are conducted which will help make the solution more real. Charts, pictures, demonstrations, reports, give meaning to the group reports.

When the solutions are presented, the interest is high because they are pupil planned. As a result of their findings the class will come to a realization that more is to be learned. This will help to motivate further study of this area in their later school life. Is this not of great value to the secondary teacher? It is training in research.

In conclusion, let us see how some of the techniques mentioned can contribute to secondary school science:

1. Utilization of Children's Questions about the Environment
   a. Stimulates the spirit of inquiry. This spirit grows with the years and at the secondary level provides the secondary teacher with children ready to challenge and question. This is the very basis of good science instruction.
2. Experimentation
   a. The use of critical thinking, the weighing of evidence, the

using of science materials are well developed, and the secondary teacher can further his work because of this.

3. Science Interest Table
   a. Awakens interest in natural and physical objects, forces, and the applications of them in our lives.
4. Observation and Identification
   a. Trains the powers of observation—the child views things critically.
5. Group Planning
   a. Provides the opportunity to make contributions in the democratic fashion. It further provides opportunities for creating and developing individual interest.

In the final analysis our objective in education is to develop intelligent citizens to take their places in society. Elementary science has a contribution to make toward that end.

APPROXIMATE NUMBERS

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Count, measure, and irrational numbers. How many people are there in a room? You count 7, I count 7; there are 7 people.

How long is a board? You measure and report 3 feet 2 11/16 inches; I measure and report 3 feet 2 3/4 inches. We repeat the measuring process and again you report 3 feet 2 11/16 inches; once more I report 3 feet 2 3/4 inches. You concede it is a little longer than 3 feet 2 11/16 inches; I concede it is slightly less than 3 feet 2 3/4 inches. Well, let's call it 3 feet 2 23/32 inches, shall we?

What is the ratio of the circumference of a circle to its diameter? Answer: it is π. What is the value of π? It is 3 1/7 but not exactly; it is 3.1416 but not exactly: it is 3.141592 but not exactly. What is the ratio of the diagonal of a square to a side? Answer: it is $\sqrt{2}$. What is the value of $\sqrt{2}$? It is 1.4, or more accurately 1.41, or 1.414 but none of these decimal values is absolutely accurate.

In these examples, 7 is a count number, that is, a number derived by counting. Its accuracy does not depend upon the person doing the counting (assuming he is not quite illiterate mathematically). 3 feet 2 23/32 inches is a measure number, that is, it is a number derived by measuring. π is a limit number, that is, it is the limit of the ratio of the perimeter of a regular polygon to the diameter of the circumscribed circle as the number of sides of the polygon is increased without limit. $\sqrt{2}$ is a diagonal number, that is, it is the length of the diagonal of a square one unit on a side.

π and $\sqrt{2}$ are irrational numbers; 7 is an integer; 23/32 is a fraction. All of these numbers are alike in the respect of being real numbers, but, as is easily seen, they are quite diffreent in certain other respects. So long as we operate with numbers in one class, there is no great difficulty, but mathematical trouble arises when we have to combine numbers of different classes, or when we try to express a number of one class in terms of a number of another class, as when we try to express the irrational number π in terms of integers and fractions. Trouble of another kind arises when we deal with numbers of one class according to rules meant to apply only to numbers of another class; for example, when we multiply two measure numbers as if they were count numbers. The principles of computation with count (that is, exact) numbers are very simple and well known. It is the purpose of this paper to discuss some of the essential rules to be observed when we deal with measure numbers.

Exact numbers and approximate numbers. Count numbers are exact numbers; measure numbers, irrational numbers, and many common fractions reduced to decimals are approximate numbers.

How we measure. When we measure volume, we apply a unit of volume and count the applications. When we measure length, we apply a unit of length and count the applications. In general it is not possible to say that a given length contains an inch unit exactly 7 times, but it is possible to say it is nearer to 7 than to 6 or to 8. That is, we can say the length is not more than half an inch more or half an inch less than 7 inches. The accepted way of writing this is (7 ± 0.5) in. The person reading this measurement may feel that the one reporting it should have come much closer to the actual length than he did. Very well; suppose he had made the measurement in sixteenths of an inch, that is, his unit of measure is one sixteenth rather than one inch. He is now able to report the length to be (112 ± 0.5) sixteenths, indicating that it is nearer 112 than 111 or 113 sixteenths. In practice one would probably record this as $(7 \pm .03)$ in.

Measurement of the diameter of a crank shaft would probably be done with a vernier caliper or a micrometer caliper either of which gives readings correct to thousandths of an inch, that is, one can be certain a measurement is not more than one half of one thousandth of an inch more or less than the apparent reading. The accepted way to record such a reading is, for example, $(1.527 \pm .0005)$ in.

Apparent error. The number, such as $\pm .03$ in. or $\pm .0005$ in., which indicates the upper and lower limit of the dimension is called the apparent error. It is *an essential part of every measure number.*

How should one interpret a measurement which is reported without the apparent error? In such a case one can assume (a) absolute precision, or (b) an apparent error which is reasonable for the meas-

urement given. For example, if a measurement of one yard is reported, it would not be reasonable to assume an apparent error of 0.5 yd., or 0.5 ft. Usually an apparent error of 0.5 in. would be a reasonable assumption, and the measurement might well be taken as $(1 \pm .01)$ yd.

Precision. The smallness of the apparent error is an indication of the *precision* of the measurement. Otherwise stated, precision is inversely proportional to apparent error.

For example, if a road is measured to be (4226 ± 0.5) ft. long; there is an apparent error of 0.5 ft. If the diameter of a round hole in a diamond is measured to be $(.075 \pm .0005)$ in., there is an apparent error of .0005 in. Hence, the second measure is much more precise than the first.

Accuracy. The smallness of the apparent error per application of the unit of measure is an indication of the *accuracy* of the measurement. Another way to state this is to say that accuracy is in inverse ratio of the apparent error to the number of applications of the unit of measure.

For example, in the case of the road which was measured to be (4226 ± 0.5) ft. long there is an apparent error of 0.5 ft. in 4226 applications of the unit of measure, or an error of .00012 ft. per foot. In the case of the hole in the diamond which was measured to be $(.075 \pm .0005)$ in., there is an apparent error of .0005 in .075 of the unit, or an error of .007 in. per inch. Hence it is seen that the road measurement is more accurate while the diamond measurement is more precise.

Rounding off numbers. A number written down to record the result of a measurement may suggest a degree of accuracy that is not justified by the facts, or that is not usable or wanted. Hence, it is often necessary to "round off numbers." Every complete school course in elementary arithmetic teaches how this rounding off is done. There is one variation from the rules there learned that is sometimes used; that is to make the digit preceding a dropped 5 an even number. Thus 2.75 rounded off to tenths would, according to this rule, become 2.8, but 2.65 rounded off to tenths would be 2.6. This practice is not uniform and should not be encouraged.

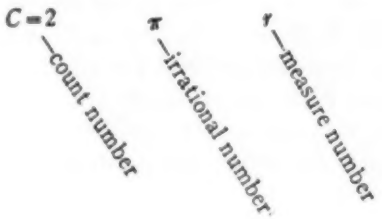
It is obvious that rounding off increases the apparent error and consequently decreases the accuracy of the number.

Significant digits. Degree of precision. Degree of accuracy. The degree of precision of a measurement recorded in decimal notation is usually indicated by the number of significant digits in the decimal fractional part of a number expressing the measure. In a properly recorded measurement, any digit other than zero is always significant. A zero between two significant digits is a significant digit. A zero that has no significant digit to the left of it is not significant. A zero that

has no significant digit to the right of it is not significant unless it is indicated in some manner that it is significant. The fact that a zero is significant is sometimes indicated by underscoring it, as 5̲0. Zeros which are not significant are sometimes printed in smaller type to indicate this fact, as 5o.

The degree of accuracy of a measurement is indicated by the number of significant digits, regardless of the places in which they stand. That is, 1256, 20.47, and .003472 are considered to have the same degree of accuracy.

Combining numbers. We find it constantly necessary to combine numbers by addition, subtraction, multiplication, and division; count numbers with count numbers; count numbers with measure numbers; measure numbers with irrational numbers; count, measure, and irrational numbers all together. What kinds of results do these various combinations yield? Exact? Approximate? What degree of approximation? Are there principles and rules to guide us in making the various number combinations?



Rules and reason. Elementary school training is confined almost exclusively to combining exact or count numbers. In dealing with measure and irrational numbers we need the guidance of new principles. Some of these principles are quite simple and should be constantly in mind; some are not so simple and are best applied when reduced to rules. As is generally true, one should never work by rule so long as he can work by reason.

Computation principles. When using approximate numbers, a few simple principles should be kept constantly in mind.

I. *Use good judgment to guide you.* In a particular situation, are you justified in using $\pi = 3.141592$? Does the accuracy of the data justify this? Does the required accuracy of the result demand it? Would $\pi = 3.14$ be a more reasonable value to use here? In another situation, does $\sqrt{2} = 1.41421$, or would 1.4 be a more reasonable value to use? Consider the computation rules given below before deciding which values to use.

II. *The degree of precision of the result of a computation is determined by the degree of precision of the measure numbers used, and by that alone.* In other words, the result cannot be any more precise than

is justified by the measure numbers used. One cannot gain precision by mathematical manipulation. If the length of the diameter of a circle is known within one-tenth of an inch, one cannot determine the circumference to hundred-thousandths by using the value of π accurate to five figures.

III. *The sum of approximate numbers cannot be more precise than the least precise addend.* To be sure, one can add 1.2 inches to .034567 inches (the numbers precise to tenths and millionths respectively), but in the sum 1.234567 only the first two digits are known to be correct, because 1.2 is not known to represent 1.200000 which is assumed in the addition.

Computation rules. The principles set down above justify the following rules of computation with approximate numbers.

Rule 1. Addition and subtraction. Add or subtract approximate numbers as if they were exact, then round off the result to agree in degree of precision with the least precise of the numbers combined.

Rule 2. Multiplication and division. Multiply or divide approximate numbers as if they were exact, then round off the result to the same number of significant digits as in the number having the least number of significant digits that entered into the computation.

These computation rules are variously stated by different authorities. As here stated, they are easy to understand and apply although they sometimes give a somewhat exaggerated appearance of accuracy.

GIRLS AND GRADES CONTINUED

JOHN B. UNDERWOOD

Registrar of Eligibility, California Scholarship Federation, Grass Valley, California

These further comments were inspired by the excellent article, "Girls and Grades," by Dean Lobaugh which appeared in the December, 1947 issue of SCHOOL SCIENCE AND MATHEMATICS. As a matter of fact, after reading the article and also being in position to easily secure further data and contributions from others, I was prompted to continue this research.

As a background for further remarks, let me state briefly what our organization is. The California Scholarship is an honor society organized over twenty-five years ago for the purpose of encouraging a high standard of scholarship among students of the various secondary schools of California. Chapters have been added from time to time until it has now reached Number 384. This includes most of the high schools of the state and involves a total enrollment of more than

200,000 students, 10,000 of whom belong to our scholarship societies. While membership qualifications are rather high for academic subjects, we do recognize extra-curricular activities. This is evidenced by our motto, "Scholarship for Service." Using the five point grading system, an A counts three points and a B one. Points are not given for grades below B. Ten points are required for membership, eight of which must be in classroom subjects. The student who maintains CSF standing throughout his high school course achieves considerably more than the standard required for admission to the University.

In this survey cards were sent out to all the Chapter Advisers, requesting reports on Chapter and School enrollment. The results to date from reports of 148 chapters are as follows:

	Boys	Girls	Total
High School Enrollment	58,713	60,307	119,020
CSF Chapter Enrollment	2,058	4,481	6,539
CSF Percentage (approx.)	3.5%	7.4%	5.56%

This agrees with data reported by others. However, I found that about ten percent of Chapters had a membership of approximately equal numbers of boys and girls. So I wrote to the Advisers of these Chapters, reporting the total results and requesting them to write me explaining how they achieved their results. I also asked for expressions of opinion regarding the general data.

The replies were too varied to summarize at this time. However, the schools which are able to maintain an even balance, seem to put forth special effort to motivate boys in academic studies. Some of these schools are located in college towns and hence the boys are motivated by the desire to be able to enter college. These schools, while recognizing the importance of extra-curricular activities, are more careful about preventing such activities from disrupting classroom work than schools whose boys do not seem to fare so well academically. It would appear in many cases that interruptions of classroom work interfere less with the success of girl students than boy students.

In conclusion then, I feel that the solution of this problem is not so much that of grading as of uninterrupted class sessions and motivation of academic work. It is the problem of the administrator as well as the teacher. We may have to modify the objectives of many of our courses so that they may meet the challenge of the boys who will respond when their interests are motivated by what seems to them worthwhile.

What a test reveals: "Isotope—a unit of electricity used to bombard atoms."

DEVELOPING UNDERSTANDING IN JUNIOR HIGH SCHOOL ARITHMETIC

MAXINE DUNFEE
Indiana University, Bloomington, Indiana

We have been hearing during the past months much about building understanding in arithmetic. All of us who teach have always hoped that we were helping children to understand their arithmetic. We are beginning to wonder, however, when we enter our junior high school classes and discover that many of our boys and girls somewhere along the way failed to develop that understanding we thought we were teaching. We very naturally put the blame upon the teachers who preceded us, or put it upon the children themselves. We are inclined to start today with our textbook and to go ahead saying to ourselves, "Well, if they didn't get it in seven or eight years, there is no point in trying to teach it now." In this way the snowball of misunderstanding or lack of understanding becomes larger and larger.

We need to look at the problem of understanding in a different sort of way. We need to try to find out why our junior high school children sometimes come to us with so little background in the fundamental processes—even those with whole numbers and with fractions. As one visits in many kinds of schools he is impressed by the overwhelming emphasis upon computation in arithmetic. We have felt all along that there was a certain virtue in being able to find the answer to arithmetic examples quickly and correctly. We concerned ourselves little if assignments were completed on time and with reasonable accuracy. We have not asked, "Why did you do this?" or "How did you do this?" We have merely checked wrong answers and returned the papers for correction. The cycle of work, check, rework began. We have criticized the ultramodern school for making arithmetic something incidental, for waiting until the right situation arose, for insisting on a felt need. Somewhere in between these two extremes—purely computational learning and incidental learning—lies the real importance of arithmetic. Mathematics is a system. It must be learned as a system. On the other hand, mathematics is useful only as it helps us to solve the problems of everyday life. Therefore, we must put those two ideas together in our teaching of arithmetic. We must learn the system, knowing how it is made and how it works; and we must use the system as often as possible in real or at least life-like situations.

The first thing to look at in thinking about understanding in arithmetic is the child. We must know something about his growth and development, his abilities, and his needs. Arnold Gesell has been

most helpful to us in this area. Through records built on years of observation and study he has tried to show how a child's concept of number grows. He describes the patterns of behavior that are characteristic of the child's development through the pre-school and school years. For example, at twelve months of age, "one by one" is the rule. The child handles one object at a time and centers his attention there. At two, he is interested in several blocks or several toys at one time; he may ask for "another" of something. At three, the rudiments of counting may appear; "two" has meaning for him. When four comes along, counting three or four objects may actually be accomplished. The child holds up fingers to show his age and gives other evidences of understanding very simple numbers. At five, counting more objects is possible. The child likes to write numbers, too, though some may be incorrectly formed. And so it goes. Each year brings some new development in the understanding of numbers, some new ability to manipulate the system.[1] The tracing of such development is most enlightening to those of our junior high school teachers who have not given thought to the life of the child before he came to junior high school.

A knowledge of a child's growth and development combined with a sincere desire to develop an understanding of numbers goes hand in hand with the building of useful concepts in mathematics. Our chief problem in the junior high school is the child of normal ability who just doesn't understand his mathematics. We wonder why. Perhaps these are some of the reasons. Maybe he has learned his arithmetic by rote. The teacher has said to him, "This is how we mulitply by two figures. Now follow me and do it as I did." Perhaps the child has thought of arithmetic as a bag of tricks. For example, in dividing with fractions he learned to invert the divisor and multiply. It was a curious and very interesting thing to do, because if one were careful he would secure the right answer. It was a trick. It is quite possible that some of our junior high school children have no idea of our number system. Some of our children have never had a chance to see how it really operates; they do not know that it is a system with certain possibilities because of its decimal character; they do not understand the basic importance of counting; they see no relationships between the processes. They do not know that shopping for mother or taking care of their own small allowance or finding out when to return a book to the library are all real arithmetic experiences. To them arithmetic has been a page in a textbook and work in the evenings at home. These children have depended upon their memory or directions in the book (or upon poor father and mother!)

[1] Gesell, Arnold, and Ilg, Frances L., *The Child From Five to Ten.* New York: Harper and Brothers, 1946.

to solve arithmetic problems and examples. When memory fails they have had no other resource.

If this describes the children who ought to be getting their arithmetic, perhaps we can think of some things to do about the situation. We have no right to assume that any junior high school child who comes to us has a body of arithmetical knowledge already learned. We have found out to our sorrow that entrance into the seventh grade does not mean that the child knows all the fundamental processes in whole numbers, fractions, and decimals. This is as it should be. Each child who comes to us is an individual who has had varying experiences in the world of numbers. We can not *count* on his knowing anything at all. In this enlightened day when we no longer retard children year after year for failure in arithmetic, we cannot demand that each child should fit the mold. We can identify very soon in our classes the boys and girls who do not know anything about the number system. We may say, "In junior high there just isn't time to teach the number system; there are too many things to learn in percentage and measurement and problem solving." When we say this, however, we are depriving the child of the fine opportunity of looking backward. The first thing we must do for him is to build up his background of experience with the number system. Here it may be profitable to look at some of the techniques that are used with elementary children in their first introduction to the number system. Throughout these experiences we emphasize the basic character of counting, the importance of place value, the idea of tens, and the place of the zero. Through utilization of all the number situations that arise in the primary grades, we count—how many are absent, how many will stay for lunch, how many bottles of milk do we need? We make counting useful whenever possible. We read numbers and write numbers in meaningful situations—the pages of our books, the numbers of our lockers, the dates in our letters. We measure when we cook; we add when we buy food for our party. We use an abacus—a simple one made of beads on coat hanger wire—to teach place value. Manipulation of such a concrete object is fun and has many values. We have bright colored sticks which fit into our stick board. The board visualizes place value of numbers for us. There are places for 9 single sticks—the ones; places for 9 bundles of ten sticks each—the tens; places for several bales of 10 bundles each—the hundreds. Carrying in addition and borrowing in subtraction take on new meaning when one can *see* the operation concretely.

Many of these ideas will be surprisingly new to our computation-minded junior high boys and girls. At their maturity level they can grasp quickly ideas that were perhaps unthought of before. The teacher will have the fun of seeing boys' and girls' faces light up with

interest when he gives them some hints about how our number system was built and how it operates. When the child says, "Well, I never knew that before," we know that he has taken a step toward a new comprehension.

As part of this building of background we must not forget to tell the children something about how numbers came to be. Too often our students feel that arithmetic has no roots, that it is something that has been thought up by man just to make school difficult, that it is different from history or art or music. Arithmetic does have a beginning and a history. The fascinating stories of how it all came about can help to intensify the interest of children who have been bored by pages of examples and long lists of problems. The stories of the beginnings of counting, the origin of our number words, the development of zero, the bases for our common measures, all may be used to build understanding and improve attitudes toward arithmetic. We have much fine help given us in these areas by such writers as Spitzer,[2] Brueckner and Grossnickle,[3] and others. Our modern authorities have tapped many resources to aid us in giving meaning to arithmetic.

As we are trying to do the two things just mentioned, we must try to make arithmetic real to the child. He must see the arithmetic that he does in class operate in life. He must see the number problems with which he wrestles at home brought into the classroom. Most of our children see school experiences in numbers as something entirely separate from real living. Most boys want to know the baseball percentages of their favorite teams. Most girls would be interested in doing the fractions which are involved in cooking. We should put into our mathematics the kinds of number experiences which will fit the needs of children. If we need to measure for a new baseball diamond or decide what percentage of our weekly allowance should be spent on candy, then there is a real chance to use those experiences as an introduction to or as a utilization of the skills which we think children should have.

As children begin to see that arithmetic is something useful and real, they can learn certain techniques for solving their problems. For example, a written problem in the textbook will have much more meaning when a child begins to see it as a situation that has *real* meaning. If he can make a diagram of the situation or illustrate it in some simple way, he has transferred words into meaning. He will see some point to trying to estimate the answer, for that is what we always do in life when we are doing mental arithmetical operations.

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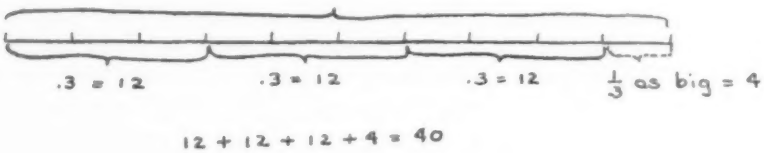
[2] Spitzer, Herbert, *The Teaching of Arithmetic.* New York: Houghton Mifflin Co., 1948.

[3] Brueckner, Leo J., and Grossnickle, Foster E., *How to Make Arithmetic Meaningful.* Philadelphia: John C. Winston Company, 1947.

He will analyze the answer to see if it is reasonable. The processes themselves will have new meaning. The little boy who went to the board to find out how many 5¢ ice cream cones could be bought for 15¢ and secured the answer "75" saw the light of day when the teacher gave him the 15¢, saying, "That's fine, Billy, go and get the ice cream cones, and there will be two for each one in the class." When Billy said, "Oh, you really mean it," he was referring to something in the class that had been only a number operation. We need to find some way to transfer the problems into real situations. For example, this child's illustration gives meaning to the question "How many chairs can six boys bring from the music room, if each carries two?"

=12 chairs. At the junior high school level the problem may read, .3 of what number is 12? The line represents the number. It is divided into tenths. If .3=12, .1=4. The number is 40.

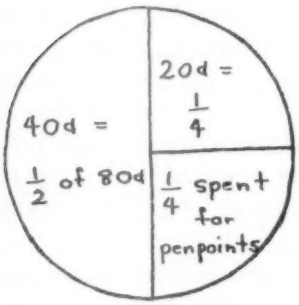


One of the important needs of junior high school students is to feel success and security in what they are trying to do. Every time we say, "Now listen carefully; today we are going to have something new," we throw the slow-working child into a spasm of terror. Almost at once he feels that here is something that he can not do. But if we take some time to put the number system actually to work, we will soon discover that children can solve almost any new situation with the information that they already have at hand. We have had many proofs of this. In elementary classes it has been a great satisfaction to watch children solve problems involving two figure multiplication long before they have ever been instructed in the multiplication process. We have often seen children adding and subtracting fractions without ever having been shown the method. True, they have not, of course, used the "accepted" form. It would be impossible for them to guess our complicated plan for recording thinking. But by using knowledge at hand children can solve new steps in their own ways. Then when they have had that success, they are ready to learn rather

quickly the technique or algorism. Once we have convinced the children that mathematics is systematic and continuous, we have gone a long way in giving them a chance to succeed. All this means that we introduce all new processes by letting children try their hands at "discovering" the answers and perhaps "discovering" an economical way to set down the examples. Many of our children have been so much interested in this way of approaching arithmetic, that they have become quite impatient with a teacher who starts to say, "This is the way to do it."

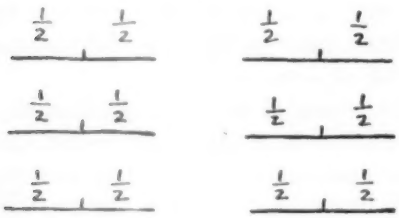
We have gone a step beyond this to utilize children's proof. We ask them, "How do you know?" or "Can you prove it concretely?" At this level a child's proof might look like this. As you can see, it goes beyond mere "checking," which, although good, is merely a re-manipulation of numbers.

1. Ruth has 80¢. She spent 40¢ for pencils and paper, 20¢ for ink, and the rest for penpoints. What part of her money was spent for penpoints?



$\frac{1}{2}$ the money was spent for pencils and paper.
$\frac{1}{4}$ the money was spent for ink.
$\frac{1}{4}$ the money was spent for penpoints.

2. George buys fish food in 6-ounce packages. If he feeds it at the rate of $\frac{1}{2}$ oz. a day, how long will a package last?



——— = one ounce
12 halves = food for 12 days

We need to give some attention also to the opportunities for teaching mathematics in the other junior high school subject areas. How often we wish we could give these slower students twice as much time a day as we have for them. It is possible to work with teachers in other departments to utilize to the fullest extent the arithmetic sit-

uations which arise in their classes. Science and social studies are full of such opportunities, and a closer working together of teachers would make the task of each much easier. Constructing the time line in history, using the slide rule in science, accurate measuring in chemistry—all are live mathematical situations, taught in mathematics class but practical elsewhere.

We cannot leave the slow student to his plodding way without thinking about him in relation to the textbook. The textbook is an anathema to him. It assumes bigger and bigger proportions in his life, because he carries it home so many evenings for extra work. Can he do arithmetic without the textbook? He is the child who needs to see and start on new processes without the textbook. He is the child who needs to feel that the textbook is for practice according to his own needs. He is the child who can be led to look to the textbook as a source of test situations which will point up his own needs or as a reference for individual help.

And last of all we must emphasize again that not all junior high school students are able to start in mathematics in the same place or to progress at the same rate. Many of these children have been used to group work in the elementary school. They have been taught to work at their own speed. We will often need to continue at the junior high level with assignments that differ not only in amount but in *kind*. There is no reason why we can not locate those boys and girls who need new understanding and background, work with them apart from others if necessary, helping to pick up some of the ideas that they have lost along the way or have never acquired.

Now, a word of warning. Understanding with children does not happen in a day. It is something that grows. Children who have always been closely directed, told what to do, assigned pages of examples, who have never known arithmetic as anything but a textbook exercise will, of course, react in the old pattern. Understanding must be taught systematically, as well as at every opportunity. It must be demonstrated concretely. The values multiply as children go more deeply into new procedures and explore new ideas.

Have we really helped the slow but normal boy or girl to understand junior high school work? We have helped him if we do not expect him to cover every page of the book before the end of the semester, if he realizes that arithmetic has a foundation in the past, if he understands that number is systematic, if he is engaging in real experiences where a number is useful, and best of all if he has a new feeling of security and success. The ideas here expressed are not new. Sometimes it helps to think through them once again.

A MODULATED LIGHT TRANSMITTER AND RECEIVER

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A number of high school and college physics teachers may have wondered, as they prepared and taught the simple principles and practice of radio, whether sound could be transmitted over a beam of light. The demonstration of this type of sound transmission would arouse keen interest, and would make possible the operation of a complete transmitter and receiver without licensing by the Federal Communications Commission.

The writer became interested in this problem about a year ago. At that time he did not know that sound over light transmission was practicable, nor that R.C.A. engineers had demonstrated it at the New York World's Fair. He still has not come across any account of the type of transmission where the actual production of light at the source is modulated. Sound is sent a very short distance over light in any standard sound projector, but there the original amount of light emitted by the lamp remains constant. The sound track on the film varies the amount to reach the photoelectric cell which constitutes the first stage of the receiver. Because he had not come across any account of light source modulation the writer decided to try to develop a transmitter applying that principle. It seemed clear that a good electronic-type modulated-source transmitter should avoid all mechanical parts having inertia, and thus should be capable of very high fidelity transmission. To develop a workable transmitter and receiver from scratch took the writer two or three weeks of his time after classes and during between-quarter intermissions.

As the problem was completely new to the writer, he was not sure at the beginning, what type of light to use, nor what approach to the problem of modulation would prove most fruitful. To avoid mechanical inertia, he discarded the possibility of using a moving mirror or some other mechanical modulator. Because it seemed that the oscillations involved in sending voice and music would be too rapid for a heated filament to follow exactly, the idea of modulating the current to a conventional light bulb was soon dropped. To respond to such rapid vibrations it seemed logical to use some type of light source which operated electronically. Of such sources, the neon bulb proved to be too weak a radiator of light, so the fluorescent tube seemed to offer the best chance of success.

The 15-watt tube used in a conventional fluorescent desk lamp

proved to be of suitable size and to radiate enough light for experimental purposes. It was found that a "burned-out" 15-watt fluorescent tube lit if 8 to 10 volts was applied to the one heater element which was still good, about 100 volts was impressed across the lamp terminals and one terminal of the lamp was given a flick of current from an induction coil to start conduction. Both the induction coil and the heater current could be disconnected as soon as the tube lit, and it continued to function normally. Of course every relighting of the tube required the same procedure.

It was found that the lamp could be used directly as the load in the plate circuit of a 6C5 amplifier tube. When it was so used the total B voltage used across the tube and the lamp was about 300 volts. Under such conditions the amplifier and fluorescent tubes functioned nor-

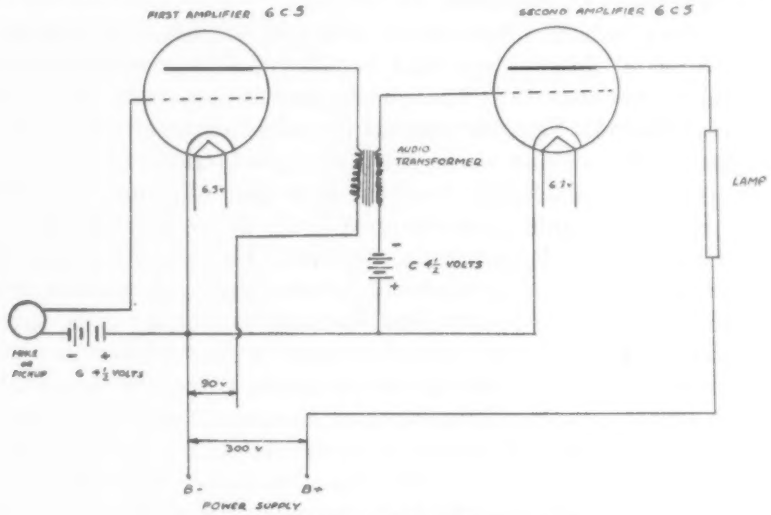

FIG. 1. Modulated Light Transmitter

mally. To modulate the 6C5 tube and thus the output of the fluorescent tube satisfactorily, one stage of audio amplification was used before the stage already described. The apparatus was connected as in the accompanying Figure 1. Electric vibrations corresponding to the original sound come from the microphone or phonograph pickup to the grid of the first amplifier tube. Some plate voltage less than 300 must be used, as that voltage is excessive for this tube. The amplified oscillations are passed along to the grid of the second amplifier tube by an audio transformer, and the resulting output is used in the fluorescent tube. When functioning normally, the light can be seen to flicker noticably as loud sounds hit the microphone.

The receiver, employing a standard photoelectric cell, posed as many problems for the writer as did the transmitter. Of course any

sound projector incorporates a satisfactory light receiver. However, the circuits are too complex for a simple demonstration such as this was intended to be. After considerable experimentation the writer evolved the circuit shown in Figure 2. It worked quite satisfactorily. It is necessary to use grounded shielding around all of the photoelectric cell except the glass window, and around the amplifier tube control grid leads to avoid picking up a great deal of undesirable interference in the receiver.

When the receiver photoelectric cell is placed any considerable distance from the transmitter, a large concave mirror or a large convex lens should be used to focus as much light as possible on the cell's sensitized film. As the writer had no very large lens or mirror he used two concave mirrors of about three inches diameter at a distance ten

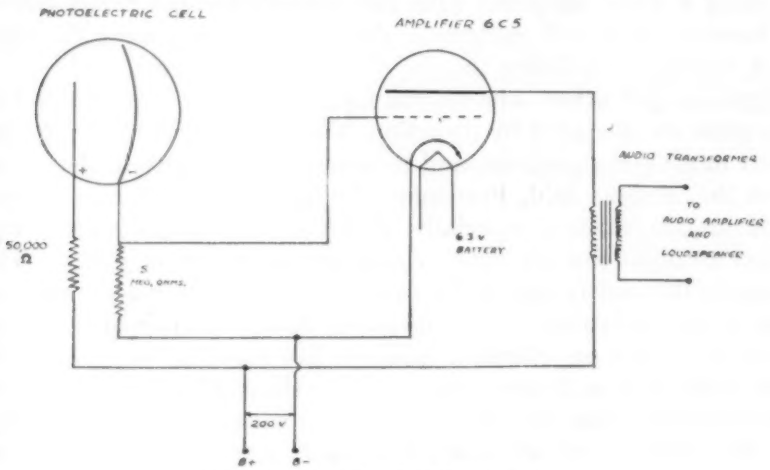

FIG. 2. Modulated Light Receiver

feet from the transmitter, in such a position that they focused the image of the lamp on the photoelectric cell. The variations in the light are turned into a varying electric current by the photoelectric cell. This current is amplified by another 6C5 tube. The amplified current is then sent on to a regular audio amplifier and loudspeaker through an audio transformer. The writer attached the secondary of the transformer to the grid of the first audio amplifier tube of an old standard radio receiver, and the result was quite satisfactory. During almost all of the work the pickup leads of a cathode-ray oscillograph were also connected across the secondary of the transformer. The oscillograph was essential to show very faint signals before the circuit was brought to a satisfactory stage. When the apparatus was working well, the oscillograph showed the wave-form of the sound beautifully, and served to demonstrate the presence or absence of distortion

in the transmission of a simple musical sound, such as that from a tuning fork. The oscillograph showed that whenever the flourescent lamp was running, it produced, independently, an oscillation of about 1000 cycle frequency. The loudspeaker reproduced this as a weak but audible whistle. The writer has not yet discovered why the lamp produces this oscillation when operating on direct current from the amplifier plate circuit.

It was found that the most satisfactory performance resulted when the sound was first recorded on a tape recorder, then, on the playback, the output from the recorder was impressed on the grid of the first amplifier tube of the transmitter. This suggests that a more powerful amplifier should be used in the transmitter when a microphone is being used direct. Probably good results could be obtained by using a sound projector with the photoelectric cell taken out of its housing, while still connected, shielding it and focusing the light on it, in place of building the above-mentioned receiver.

Students and others who see the light transmitter and receiver in operation are intrigued by its action. The demonstration arouses interest in radio transmission and reception, particularly in the short-wave line-of-sight field. Principles of modulation, transmission and reception are clarified, especially when the oscillograph is used. The actual modulations are made visible in the fluctuating light. The photoelectric cell is seen to be capable of responding accurately to tiny, rapid oscillations in the incoming light. The principles of the sound projector are clarified. Students see that the possibilities of new types of long-distance transmission through space are not yet exhausted, and that even relatively simple methods may work. They are stimulated to go on to devise suitable reflectors and circuits to give satisfactory transmission over longer distances. The higher frequencies of the electromagnetic spectrum are seen to be suitable for the transmission of messages. Is it possible that these frequencies may soon be in use for the transmission of our entertainment programs or commercial messages?

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2093. *Hugo Brandt, University of Maryland.*
2090, 1, 2. *V. C. Bailey, Evansville, Ind.*

2095. *Proposed by Charles W. Trigg, Los Angeles, Calif.*

Show that in a nine-celled magic square the central element must equal one-third of the constant. (The constant is the sum of the elements of any column, row, or diagonal.)

Solution by M. I. Chernofsky, The City College of New York

The elements of the "general" nine-celled magic square are

a_1	b_1	c_1
a_2	b_2	c_2
a_3	b_3	c_3

its "constant" being S. Then the four sums involving the central element, b_2, are

$$a_1+b_2+c_3=s$$
$$a_2+b_2+c_2=s$$
$$a_3+b_2+c_1=s$$
$$b_1+b_2+b_3=s.$$

Adding the above, grouping properly, we have $a_1+a_2+a_3+3b_2+c_1+c_2+c_3+b_1+b_2+b_3=3S+3b_2=4S$, and $3b_2=S$.

Solutions were also offered by Robert E. Harton, Los Angeles; Mr. Wernick, New York; Wm. A. Richards, Riverside, Ill.; W. J. Cherry, Berwyn, Ill.; Felix John, Ammendale, Md.; Max Beberman, Shanks Village, N. Y.; the proposer; also V. C. Bailey, Evansville, Ind.

2096. *Proposed by Roy Wild, University of Chicago.*

If $\alpha+\beta+\psi=180°$, show that

$$\begin{vmatrix} \cos\alpha & \cos\beta & \cos\psi \\ \csc\alpha & \csc\beta & \csc\psi \\ \sec\alpha & \sec\beta & \sec\psi \end{vmatrix} = 0.$$

Solution by Aaron Buchman, Buffalo, New York

It is easily shown by elementary trigonometry that if

$$x+y+z=180°, \text{ then } (\sec x)\,(\csc y)\,(\cos z)=\tan x-\cot y \tag{1}$$

Since the given determinant is symmetrical in the three variables, it is at once seen that if formula (1) is used to replace each of the six triple products in the expansion of this determinant, the sum of the resulting twelve terms must be zero.

Note by the proposer: The trilinear coordinates of the circumcenter, centroid and orthocenter of the triangle of reference are respectively the rows of the determinate and since the points lie on the Euler line, the determinate must equal zero.

Other solutions, by expansion of the determinate were offered by Hugo Brandt, University of Maryland; C. W. Trigg, Los Angeles; W. J. Cherry, Berwyn, Ill.; Max Beberman, Shanks Village, N. Y.; Margaret Joseph, Milwaukee.

2097. *Proposed by Felix John, Ammendale, Md.*

The series of positive integers is divided into groups

$$1;\ 2,\ 3,\ 4;\ 5,\ 6,\ 7,\ 8,\ 9;\ \cdots .$$

Prove that the sum of the numbers in the nth group is

$$(n-1)^3+n^3.$$

Solution by S. E. Field, Gogebic Junior College, Ironwood, Michigan

Let

$$n=\text{the number of the group}$$

and

$$N=\text{the number of integers in the group.}$$

Then

$$N=2n-1.$$

Now each group is an arithmetic progression of $2n-1$ terms in which we may take as the first term the largest number $a=n^2$, with the common difference -1. The sum of the $2n-1$ terms of the nth group is given by

$$\begin{aligned} S&=\frac{2n-1}{2}\left[2n^2+(2n-1-1)(-1)\right] \\ &=(2n-1)(n^2-n+1) \\ &=[n+(n-1)][n+(n-1)^2] \\ &=(n-1)^3+n^3. \end{aligned}$$

Other solutions were offered by: Wm. A. Richards, Riverside, Ill.; C. W. Trigg, Los Angeles; W. J. Cherry, Berwyn, Ill.; Francis L. Miksa, Aurora, Ill.; Max Beberman, Shanks Village, N. Y.; M. I. Chernofsky, New York; Aaron Buchman, Buffalo, New York; V. C. Bailey, Evansville, Indiana; and the proposer.

2098. *Proposed by Frances L. Miksa, Aurora, Illinois.*

Given

$$\frac{\sin(2x+y)}{\sin 2x}-\frac{\sin(2y+x)}{\sin 2y}=0. \tag{1}$$

Show that this equation may be reduced to the equation

$$(\cos x-\cos y)\left[\cos^2(x+y)+\cos x\cos y\right]=0. \tag{2}$$

Solution by S. E. Field, Gogebic Junior College, Ironwood, Michigan

Expanding the numerators of equation (1), clearing of fractions, and replacing

$\sin 2x$, $\sin 2y$, $\cos 2x$, and $\cos 2y$ by $2 \sin x \cos x$, $2 \sin y \cos y$, $\cos^2 x - \sin^2 x$, and $\cos^2 y - \sin^2 y$, respectively, the equation reduces to

$$2 \sin x \cos x \sin \cos^2 y - 2 \sin x \cos^2 x \sin y \cos y - \sin^2 x \cos x \sin^2 y$$
$$- \sin^2 x \cos x \cos^2 y + \cos^2 x \sin^2 y \cos y - \sin^2 x \sin^2 y \cos y = 0. \quad (3)$$

Equation (2) may be written in the form

$$(\cos x - \cos y)(\cos^2 x \cos^2 y + \sin^2 x \sin^2 y - 2 \sin x \cos x \sin y \cos y + \cos x \cos y) = 0 \quad (4)$$

or

$$\cos x (1 - \sin^2 x) \cos^2 y - \cos y \cos^2 x (1 - \sin^2 y)$$
$$+ (\cos x - \cos y)(\sin^2 x \sin^2 y - 2 \sin x \cos x \sin y \cos y + \cos x \cos y) = 0.$$

When expanded, the terms $\cos x \cos^2 y$, $-\cos x \cos^2 y$, $\cos^2 x \cos y$, and $-\cos^2 x \cos y$ drop out leaving the same form as (3) above.

By hard labor, C. W. Trigg, Wm. A. Richard and Max Beberman found solutions as given above.

2099. *Proposed by Frank Sevier, Philadelphia, Pa.*

Find a four digit number, such that the product of the extreme digits, which are equal, is equal to the number formed by the two inner digits, the sum of these inner digits being equal to one of the extreme digits.

Solution by V. C. Bailey, Evansville College, Evansville, Ind.

Let the digits be, in order,

$$x, y, z, x.$$

Then,

$$x^2 = 10y + z \quad \text{and} \quad (1)$$
$$y + z = x. \quad (2)$$

Eliminate z between equations (1) and (2) and solve for y in terms of x.

$$x^2 - x - 9y = 0 \quad (3)$$
$$y = \frac{x(x-1)}{9}. \quad (4)$$

From the form of (4), it is obvious that

$$x = 0, 1, 9.$$

Then,

$$y = 0, 0, 8.$$
$$z = 0, 1, 1.$$

The required four-digit numbers are 9819 and 1011.

Other solutions by: Wm. A. Richards, Riverside, Ill.; M. I. Chernofsky, New York; Margaret Joseph, Milwaukee, Wisconsin; Aaron Buchman, Buffalo, New York; Francis L. Miksa, Aurora, Ill.; C. W. Trigg, Los Angeles; Felix John, Ammendale, Md.; Mildred Hopkins, Kankakee, Ill.; Albert Franklin Gilman III, Chicago, Ill.; Max Beberman, Shanks Village, New York; S. E. Field, Ironwood, Mich.; W. R. Smith, Suttons Bay, Mich.; and the proposer.

2100. *Proposed by Felix John, Ammendale, Md.*

In triangle ABC,

$$\cos C / \sin A \sin B = (3 - \sqrt{3})/3, \quad (1)$$

also

$$\tan A \tan B \tan C = 3 + 2\sqrt{3}. \quad (2)$$

Find angles A, B, and C.

Solution by C. W. Trigg, Los Angeles City College

$$\frac{\cos C}{\sin A \sin B}=\frac{-\cos (A+B)}{\sin A \sin B}=\frac{-\cos A \cos B+\sin A \sin B}{\sin A \sin B}=-\cot A \cot B+1.$$

From (1):

$$\cot A \cot B=-\sqrt{3}/3.$$

So,

$$\tan A \tan B=\sqrt{3}. \tag{3}$$

Substituting in (2):

$$\sqrt{3} \tan C=3+2\sqrt{3}.$$
$$\tan C=2+\sqrt{3}, \quad \text{so} \quad C=75°.$$

Then $A+B=105°$, so from (3):

$$\tan A \tan (105°-A)=\sqrt{3}.$$
$$\frac{\tan A(\tan 105°-\tan A)}{1+\tan 105° \tan A}=\sqrt{3}.$$
$$\tan^2 A+(\sqrt{3}-1) \tan 105° \tan A+\sqrt{3}=0.$$

Now $\tan 105°=-\tan 75°=-(2+\sqrt{3})$. Substituting,

$$\tan^2 A-(1+\sqrt{3})\tan A+\sqrt{3}=0.$$
$$(\tan A-1)(\tan A-\sqrt{3})=0.$$
$$\tan A=1, \quad \text{so} \quad A=45°, \quad B=60°, \quad C=75°;$$

or

$$\tan A=\sqrt{3}, \quad \text{so} \quad A=60°, \quad B=45°, \quad C=75°.$$

Other solutions were offered by: W. J. Cherry, Berwyn, Ill.; S. E. Field, Ironwood, Michigan; V. C. Bailey, Evansville, Ind.; Max Beberman, Shanks Village, N. Y.; Wm. A. Richards, Riverside, Ill.; Aaron Buchman, Buffalo, New York; and proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

PROBLEMS FOR SOLUTION

2113. *Proposed by Walter H. Carnahan, Boston.*

Solve for x and y. (From Bowser's College Algebra)

$$(x^6+1)y=(y^2+1)x^3$$
$$(y^6+1)x=9(x^2+1)y^3.$$

2114. *Proposed by V. H. Paquet, Colton, Oregon.*

A solid sphere, radius one, is to have three circular cylindrical holes drilled through it, the holes to be equally spaced on a great circle of the sphere, the longitudinal center lines of the holes to be in the plane of the great circle. What is the radius of the drill if the net volume of the holes is one-half the remaining solid part of the sphere?

2115. *Proposed by Bessie Spillman, Dobb's Ferry, N. Y.*

A triangle ABC is inscribed in a circle, diameter d. If $d^2=a^2+b^2+c^2$, then show that $\sin^2 A+\sin^2 B+\sin^2 C=2$, and that the triangle is right angled.

2116. *Proposed by M. Y. Woodbridge, Brooklyn.*

Two ladders, 40 ft. and 60 ft. in length, cross in a verticle plane at a point 15 ft. above the horizontal. If the ladders rest on walls on opposite sides of a street, find by use of trigonometry the width of the street.

Editor's note: This problem has appeared in this department, solved by use of algebra.

2117. *Proposed by Francis L. Miksa, Aurora.*

In triangle ABC, if the angles and the sum of the sides be given show that

$$a=\frac{s\sin A}{D}, \quad \text{where} \quad s=a+b+c \quad \text{and} \quad D=4\cos\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}.$$

2118. *Proposed by Harvey Saffeir, Ithaca, N. Y.*

In a circle an isosceles triangle ABC is inscribed. On base BC an altitude is drawn meeting BC in D and the circle in E. From B an altitude is drawn to AC meeting AD in F, AC in G and circle in H. If $AF=18$, $DE=6$, find length of BH.

BOOKS AND PAMPHLETS RECEIVED

NUMBER THEORY AND ITS HISTORY, by Oystein Ore, *Sterling Professor of Mathematics, Yale University.* Cloth. Pages x+370. 13.5×20 cm. 1948. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $4.50.

A NEW GEOMETRY FOR SECONDARY SCHOOLS, by Theodore Herberg, *Head of the Mathematics Department, Pittsfield, Massachusetts High School,* and Joseph B. Orleans, *Head of the Mathematics Department, George Washington High School, New York City.* Second Edition. Cloth. Pages vii+406. 13×20 cm. 1948. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $1.92.

SWOOPE'S LESSONS IN PRACTICAL ELECTRICITY, by Erich Hausmann, E.E., Sc.D., *Thomas Potts Professor of Physics and Dean of the College Polytechnic Institute of Brooklyn.* Eighteenth Edition, Revised and Enlarged. Cloth. Pages v+769. 15×23 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $4.80.

SPHERICAL HARMONICS, AN ELEMENTARY TREATISE ON HARMONIC FUNCTIONS WITH APPLICATIONS, by T. M. MacRobert, M.A., D.Sc., *Professor of Mathematics in the University of Glasgow.* Second Revised Edition. Cloth. Pages xv +372. 14×22 cm. 1948. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $4.50.

NEW WORLD OF SCIENCE, by R. Will Burnett, *Professor of Science Education, University of Illinois;* Bernard Jaffe, *Chairman, Department of Physical Science, James Madison High School, New York City;* and Herbert S. Zim, *Science Consultant, Ethical Culture and Manhasset Bay Schools, New York.* Cloth. Pages vii+504. 18.5×25 cm. 1948. Silver Burdett Company, 45 East 17th Street, New York 3, N. Y. Price $2.80.

THE MATHEMATICAL BASIS OF THE ARTS, by Joseph Schillinger. Cloth. Pages x+696. 16.5×24 cm. 1948. Philosophical Library, New York. Price $12.00.

ANIMAL FACTS AND FALLACIES, by Osmond P. Breland, Ph.D., *Associate Professor of Zoology, The University of Texas.* Cloth. Pages xvii×268. 13.5×20 cm. 1948. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y. Price $3.00.

FUNDAMENTALS OF HEALTH AND SAFETY, by Grover W. Mueller, M.P.E., MS. in Education, *Director, Division of Physical and Health Education, The Board of Public Education, Philadelphia;* and Elizabeth Chant Robertson, M.D., Ph.D., *Department of Paediatrics, University of Toronto.* Cloth. Pages ix+345. 14.5×23 cm. 1948. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $2.40.

GROWTH OF PLANTS, by William Crocker, *Managing Director, Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York.* Cloth. Pages v+459. 14.5×23 cm. 1948. Reinhold Publishing Corporation, 330 W. 42nd Street, New York, N. Y. Price $10.00.

NUCLEAR RADIATION PHYSICS, by R. E. Lapp, Ph.D., *Research and Development Board, Washington, D. C.,* and H. L. Andrews, Ph.D., *National Institute of Health, Bethesda, Maryland,* Cloth. Pages xiv+487. 14×21.5 cm. 1948. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $6.00.

MENDELEYEV, by Daniel Q. Posin, *Chairman of the Department of Physics at North Dakota State College.* Cloth. Pages xii+345. 14.5×22.5 cm. 1948. Whittlesey House, McGraw-Hill Book Company, 330 W. 42nd Street, New York 18, N. Y. Price $4.50.

PUBLIC-SCHOOL PUBLICITY, A PRACTICAL GUIDE FOR TEACHERS AND ADMINISTRATORS, by Gunnar Horn, *Head of the English Department and Director of Publications, Benson High School, Omaha, Nebraska.* Cloth. Pages xi+226. 14.5×23 cm. 1948. Price $3.50.

ELECTROMAGNETIC WAVES AND LIGHT, by Charles F. Meyer, *Associate Professor of Physics, University of Michigan.* First Part. Paper. Pages xi+83. 13.5×21.5 cm. 1948. Ulrich's Book Store, 549 East University Avenue, Ann Arbor, Michigan. Price $1.35.

TEACHING MATHEMATICS THROUGH SCHOOL SAVINGS, by Irene M. Reid, M.A., *Instructor in Mathematics at Miner Teachers College, Washington, D. C.* Grades 7–9. Paper. 31 pages. 14.5×23 cm. Education Section, U. S. Savings Bond Division, Treasury Department, Washington, D. C. Distributed free to teachers who request them.

TEACHING ELEMENTARY SCIENCE, by Glenn O. Blough, *Specialist in Elementary Science,* and Paul E. Blackwood, *Assistant Specialist in Elementary Science.* Paper. Pages iv+40. 14.5×23.5 cm. 1948. Superintendent of Documents, U. S. Printing Office, Washington 25, D. C. Price 15 cents.

BUDGETING FOR SECURITY. For Teacher Use, Grades 6–12. Paper. 23 pages. 14.5×23 cm. Education Section, U. S. Bond Division, Treasury Department, Washington, D. C. Copies free.

UNKNOWN NUTRITION

Vitamins and calories may be "household words," but a survey by the U. S. Department of Agriculture concluded that only four per cent of the housewives interviewed had "an adequate knowledge of nutrition."

The survey was made at Richmond, Va. About half of those interviewed were found to know little or nothing about nutrition. About three out of four said they were interested in more information.

BOOK REVIEWS

ELEMENTS OF RADIO, by Abraham Marcus and William Marcus. Prepared under the Editorship of Ralph E. Horton. Second Edition. Cloth. Pages xv+751. 13.5×20 cm. 1948. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $4.25.

This book has been one of the leading elementary textbooks on this subject since it first came out in 1943. It was written especially for the beginner. No previous knowledge of electricity or magnetism is assumed. The chapters are short, each one answering only one, two, or three questions. Following each chapter is a summary, a glossary of new terms, a drawing or two illustrating the new symbols used, and a short list of questions and problems. The book is in two parts, Part I discussing the principles without any use of mathematics. Step by step the theory is developed and the parts are discussed and put together until a superheterodyne receiver has been assembled. A chapter on the types of tubes follows. In the original text a short chapter on radio direction finders completed the first part. This has been replaced by a short chapter on modern radio receivers.

In Part II some knowledge of algebra and trigonometry are needed. Six chapters are used to present the ideas of the electric current leading the student to an understanding of resonant circuits. Two chapters follow on the electromagnetic wave, one each on vacuum-tube characteristics, vacuum-tube amplifiers, and vacuum-tube oscillators. A chapter for each is devoted to continuous wave transmitters and modulated wave transmitters and a final chapter on the cathode-ray tube, television, and radar.

A list of demonstrations for each chapter and an appendix of important information complete the book.

No great changes have been made in the revision except the change in one chapter and the addition of a few important topics. Minor changes have been made throughout to improve and clarify the theory. It is an excellent text for beginning students.

G. W. W.

THE WORLD: ITS LANDS AND PEOPLES, by Zoe A. Thralls, *Professor of Geography and Education, University of Pittsburgh.* Cloth. Pages xii+486. 25.5×19 cm. Photographs, maps, graphs and diagrams. 1948. Harcourt, Brace and Company, Inc., 383 Madison Ave., New York 17, N. Y. List price $3.40.

This high school text is a first course in world geography, and furnishes a functioning background for the study of history and current events. It presents the world as an integrated whole, using climatic regions as the basis of organization. The student is led to see that similar climatic factors in widely scattered part of the world present similar problems. The wheat farmer on the Great Plains of the United States, for example, has problems akin to those of farmers in the Russian Ukraine. Fruit growers in Mediterranean regions, whether in California, Chile, South Africa or Australia, have problems that are comparable. Likewise, trappers, lumbermen and miners whether in the Taiga of Alaska, Canada, Sweden, Russia or Russian Siberia, have problems that are similar.

The book contains 42 chapters, organized as 11 units. Each of the units deals with a specific type of climate. Each of the chapters making up a unit deals with a specific area. In this way the entire world is covered and a world climatic pattern evolved. The unit titles are unusual, and bound to create interest and arouse curiosity. There is appeal in ones such as: "Lands of Romance and Tragedy . . .," "Lands of Uncertainty and Danger . . .," "Lands of Opportunity and Harship . . . ."

In addition to building an understanding of world climates, the book develops an understanding of the world population pattern and the pattern of world occupations. It portrays a world of people confronted with the problems of every-

day living. It stresses the problems of interdependence.

Each unit is supplied with excellent maps, numerous photographs, climatic graphs and diagrams. The text guides the student in the use of these geographic tools. The 15 world maps are compressed sinusoidal, equal area projections. In addition to these, there are detailed maps of each area. Study questions, bibliographies, activities for a geography workshop, suggestions for building a geography vocabulary and keeping a progressive current geography notebook add much to the value of the book.

The books fills a long felt need. It develops a world viewpoint and furnishes an understanding of the world as a whole. It is modern geography at its best and will appeal to capable students.

VILLA B. SMITH
John Hay High School
Cleveland, Ohio

THE EARTH AND ITS RESOURCES, by Vernor C. Finch, *Professor of Geography, University of Wisconsin;* Glenn T. Trewartha, *Professor of Geography, University of Wisconsin;* and M. H. Shearer, *Westport High School, Kansas City, Missouri.* Cloth. Pages viii+584. 24.5×16.5 cm. New Second Edition, 1948. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. List price $3.20.

This volume is a high school textbook for courses in Physical Geography and Earth Science. It is illustrated with more than 400 maps, diagrams and photographs. It is accompanied by a laboratory manual, with sufficient work for a two semester course.

The book is up-to-date. It makes Earth Science a dynamic subject, relating it to a present day world. While it deals with such standard topics as atmosphere—wind, weather and climate; land forms—mountains, plains and plateaus; oceans and water resources of the land, these topics are given a new interpretation. An understanding of these and related topics is essential for an understanding of many current problems of importance. An intelligent solution of the problems of conservation, for example, is dependent on an understanding of such factors as surface, soils, winds, waters, erosion and the like. Likewise, problems of flood control are based on an understanding of Earth Science fundamentals.

The concluding chapter, "Major Regions and Resources of the United States," serves as an excellent summary and relates human activities to land forms, climatic factors, natural resources, etc.

Each chapter of the text has a summary, a set of excellent questions, a list of suggested activities and a list of topics for class reports. An Appendix provides supplementary materials of value dealing with the seasons; climatic data; meteorological instruments and weather maps; interpretation of maps; U. S. topographic quadrangles; rocks and minerals. There is also a list of visual materials, both silent and sound films, available as teaching tools. The sources of these materials and the places where they fit in the teaching program are indicated.

VILLA B. SMITH

GEOGRAPHY IN SCHOOL AND COLLEGE, by Joe Russell Whitaker, *Professor of Geography, George Peabody College for Teachers.* Cloth. Pages 116. 25.5×15.5 cm., 1948. Bureau of Publications, George Peabody College for Teachers, Nashville, Tennessee. List price $1.80.

This small volume is a "collection of talks to teachers of geography and closely related fields and to school administrators and supervisors." It should be read with interest and profit by all teachers of geography and by school administrators and supervisors as well.

It presents a clear and forceful picture as to what modern geography is, and what it has to contribute to a better world understanding and to more purposeful and intelligent daily living. Its twelve chapters discuss many timely subjects under captions such as, "Regional Interdependence," "Citizens of the World,"

"International Good Will Through Purposeful Teaching," "Twentieth Century Explorers," "Teaching Geography in a World at War," and "Man Remakes Geography."

In other chapters maps, pictures and statistical data are discussed. Attention is directed to many questions and problems that confront the teacher in the use and selection of such materials. The discussion of polar projections is timely. The suggestions as to the value and use of statistics, especially their use in testing for understanding, is invaluable. The suggestions as to ways in which a city may be made to serve as an excellent review in the study of economic or regional geography, have much to contribute to more effective teaching.

The chapter, "Design for High School Geography," is well worth the attention of every school administrator. The book is delightful reading, and furnishes material for thought and action.

VILLA B. SMITH

COLLEGE ALGEBRA, by E. Richard Heineman, *Associate Professor of Mathematics, Texas Technological College.* Cloth. Pages xii+359. 1947. The Macmillan Company, New York. Price $3.25.

The author states that his principal objectives in writing this text are clarity of presentation and carefully graded sets of diversified problems covering a wide range of difficulty. The first 163 pages of the book provide a thorough review of the topics usually covered in intermediate algebra. This section should meet the needs of students who have had inadequate training in previous courses as well as those who have forgotten some of their previous work.

The text treats the topics usually found in a college algebra. These include mathematical induction, inequalities, complex numbers, theory of equations, logarithms, theory of investment, permutations and combinations, probability, determinants, and partial fractions. The text has an abundance of exercise material and problems. An answer key in the back of the book gives the answers to all the exercises and problems except those numbered 4, 8, 12, etc. Tables needed in the course are included in the text. The book definitely merits the close examination of anyone looking for a new text in college algebra.

G. E. HAWKINS
La Grange, Ill.

HEAT, by Worthing and Holliday, *Professors of Physics, University of Pittsburgh.* Cloth. Pages xxii+522. 23×15 cm. 1948. John Wiley and Sons. New York, N. Y. Price, $6.00.

This textbook, the outgrowth of the experience of two well-known students and teachers of the subject, represents a welcome addition to a branch of theoretical and experimental physics, in which there was until recently a great dearth of textbooks suitable for the upperclassmen. Through this addition the undergraduate finds a medium by means of which he can approach and become acquainted with the classical as well as with the modern principles, laws and concepts of heat without the disconcerting feeling that a great gap exists between what he knows from his fundamental course in college physics and the more specialized and advanced problems of heat.

In this book one will find an excellent balance between the theoretical and experimental aspects of the subject, the theoretical part serving to give meaning to the carefully, and with abundant diagrams, illustrated experimental part which in turn gives life and substance to the fundamental laws and principles discussed in the text. This happy juxtaposition and interweaving of theory and experiment, of the experimental results and their application to industry place this book in a class by itself, in the sense that it transcends the narrow and limited scope of a classroom textbook.

The subject matter is discussed in thirteen chapters of about equal length, abundantly illustrated with diagrams, graphs and photographs. Each chapter is followed by carefully selected problems for solution, the answers to which

helpfully and understandingly, are given at the end of the text. At this point it may be suggested that the introduction of additional illustrative problems in a later edition would be greatly appreciated by both student and teacher. The titles of the chapters are: Some Laboratory Procedures, Temperature and its Measurement, The Expansivities of Solids and Liquids, The Dynamical Theory of Heat, Calorimetry, Specific Heats of Solids and Liquids, Thermal Conduction of Solids and Liquids, Thermal Properties of Gases, Elementary Thermodynamics, Change of Phase, Heat Engines, Refrigerators, and Human Power Plants, Convection, and Radiant Energy. In the four appendices, in addition to a discussion of Maxwell's equation for the velocity distribution of the molecules of an ideal gas and a discussion of properties of determinants, one will find extensive tables of basic constants in heat, of properties of materials and mathematical tables. This reviewer believes that, not only the undergraduate, but also, the experienced teacher will profit from a careful reading of this text, in which new and refreshing approaches to the subject are developed and that it would be a most valuable addition to the private library of every student of the physical sciences.

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EUCLIDEAN GEOMETRY, ITS NATURE AND ITS USE, by J. Herbert Blackhurst, *Professor of Education, Drake University*. Cloth. 210 pages. 13×21 cm. 1947. Garner Publishing Company, 617-17-19 Euclid Avenue, Des Moines, Iowa. Price $2.75.

Another attack upon the traditional plane geometry course of the secondary schools. The thesis presented is that the value of euclidean geometry lies in the contribution it can make toward the study of reasoning processes based on postulational thinking.

In Part I the nature of euclidean geometry is discussed in the light of qualitative logic, and it is not identified with either pure or applied mathematics. Consideration of truth, argument, and proof relations, together with the meaning of axioms and postulates, leads to a necessary re-statement of the fundamentals of euclidean geometry and its structure.

In Part II these considerations are applied educationally to the study of reasoning processes. Emphasis is laid upon proper planning and aims of teaching. A number of examples of teaching methods and procedures are given, together with a brief discussion of testing. The final chapter recommends changes in both organization and material content of current textbooks.

For those interested in a more explicit development of the ideas presented, the author's previous book *Humanized Geometry* and *Thinking Through Geometry* by Blackhurst and Brannan will furnish further details.

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INTERMEDIATE ALGEBRA, by Ralph S. Underwood, *Professor of Mathematics, Texas Technological College;* Thomas R. Nelson, *Associate Professor of Mathematics, Agricultural and Mechanical College of Texas;* and Samuel Selby, *Head of the Department of Mathematics, College of Engineering, University of Akron.* Cloth. Pages vii+283. 13×20.5 cm. 1947. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.60.

This text offers remedial and preparatory work for the college student desiring to enter engineering or scientific fields, but lacking sufficient training for a course in College Algebra.

The usual sequence of topics of beginning algebra up through the level of progressions and logarithms are provided. The treatment is compact and provides a psychological learning approach of graduated difficulty. Exceptional and qualifying cases demanded by mathematical rigor are handled by footnote remarks, leaving the train of development general in nature. The authors recom-

mend three to six semester hours' treatment, dependent upon class nature, but it would seem that three semester hours would suffice to cover the course with the average student entering with three semesters credit in high school algebra.

As would be expected of a text of this type, the emphasis lies upon operational procedure, rather than meaningful and logical proof developments. The traditional types of verbal problems are surprisingly included. They are afforded no special treatment other than serving as applicative examples of equation solution methods. Analytical methods for equation solutions are first presented, and then followed by graphic methods. A chapter on the complex number system is well presented as a preliminary to the study of quadratic equations. Examples of common error types are shown at intervals and practice exercises are provided. Answers are given to approximately four-fifths of the exercises. The treatment of logarithms is formal, based upon basic laws, followed by drill procedure development. The four-place table of logarithms contains proportional parts, but no mention is made of their use. Significant digits and approximate numbers are treated very lightly, with the odd-add rule used for rounding off numbers. An optional topic if furnished for the important form of standard number, with the simpler method for determination of characteristic of a logarithm.

Even though covering the same material as is usually offered in a high school course, due to its general tone and emphasis, this text would seem to be best suited for use with the type of college student for which it was designed.

W. K. McNabb

MATHEMATICS OF FINANCE, by J. B. Linker and M. A. Hill, Jr., *University of North Carolina*. Cloth. Pages viii+175+83. 13.5×21.5 cm. 1948. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $2.90.

A text planned for a one semester course for students in Schools of Commerce and Business Administration. The authors recommend a preceding course in college algebra.

The first chapter deals with interest and discount, and considers both simple and compound cases. Computational work is to be done by arithmetic and logarithms, with no mention of the use of calculating machines. It is apparently assumed that students will be familiar with operations on approximate numbers, since examples merely present approximate results without comment.

Annuity principles are first presented in terms of simple annuities, that is, those having equal payment intervals and conversion periods. Extensive use is made of time line diagrams, both as an analytic method and summary procedure. General formulas are based on series, and example emphasis upon substitution procedures. A complete treatment of simple annuities and variations of them enable the student to clearly pass to the consideration of general annuities. The general formula relations are brought sharply into focus through the use of symbolic solutions. Annuity procedures are then applied to interest-bearing debt extinction, bonds, and depreciation. A brief discussion of probability introduces life annuities and life insurance. This section is essentially an introduction, yet is more complete than is usually found in texts of this type.

The tables are well organized and clearly printed. Fractional interest rates arising from monthly periods are included in related tables. Complete five place logarithms and seven place logarithms for 1.0000 to 1.1000 are included with proportional parts. The American Experience Table of Mortality is used. Commutation columns at $3\frac{1}{2}\%$ include single premiums and annuities due.

The appendix includes topics on the binomial theorem as an approximation to a compound amount, progressions, and logarithms. Answers are provided to the odd numbered problems.

The general level of explanatory material is well presented at a student level. The exercises are both practical and comprehensive. They apply well to the principles being considered, and should provide continued interest to the student.

This should prove to be a very useful text for a broad introductory course in the mathematics of finance.

W. K. McNabb

GROWTH OF PLANTS; Twenty Years' Research at Boyce Thompson Institute, by William Crocker, *Managing Director, Boyce Thompson Institute for Plant Research, Inc., Yonkers, New York.* Cloth. Pages v+459. Reinhold Publishing Corporation, 330 West 42nd Street, New York 18, N. Y., U. S. A. Price, $10.00.

This book tells in an interesting way the results of twenty years of research work at the Institute on the growth of plants and their production of materials which are of economic use to man or contribute to his enjoyment. It is illustrated with 171 figures, eight of which are colored plates. The figures mostly show photographs of experimental plants and apparatus and graphs of data. There are also 48 tables.

The larger problems discussed are—yellows and virus diseases of plants, duck food problem, life span of seeds, physiological effects of ethylene and similar gases, effects of certain lethal gases on plants and animals, plant hormones, dormancy in buds, plant cell membranes, growth of plants under controlled conditions, and preparations that will kill fungi and insects that are injurious to plants or are an annoyance to people.

The selection of problems and the plans for working on them reflect the ideals of the founder, William Boyce Thompson, who provided an endowment, and of the director and his colleagues. The founder believed in the social value of science and the director and his colleagues believe that any project attacked should be studied in all its relations including its meaning in nature, in agriculture and in the industries. The work involved the use of a large amount of expensive equipment for the control of environmental factors in the growth of plants. Among the factors controlled were temperature, the intensity and quality of light, and the composition of the atmosphere surronding plants either growing or dormant.

Among the specific problems whose solution is reported in the book are—the effects of storage conditions on the content of sugar and other foods in potato tubers, the prevention of brown color in potato chips, the effects of ethylene on the ripening of fruits, the causes of dormancy in seeds and buds including methods of breaking the dormancy, methods of securing good rooting in cuttings, the effects of hormones on the form and structure of plants, and the means of restoring the growth of aquatic plants which provided food for migratory ducks, geese, and brants in a region in which the growth of these plants had been interfered with by man's activities.

The results recorded and their discussion in the book indicate that the ideals of the founder are practical when carried out according to the plans devised by the director and his colleagues.

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ANALYTIC GEOMETRY, by Roscoe Woods, *Associate Professor of Mathematics, State University of Iowa.* Revised Edition. Cloth. Pages xiv+322. 14.5×22 cm. 1948. The Macmillan Company. Price $3.50.

The text is a revised edition of a book published in 1939. The original plan has been kept with minor changes in the first chapters. Some of the exposition has been improved. The exercises have been revised with regard to arrangement, data and wording. Also, new exercises have been added.

The work is a strong standard first course in analytic geometry with additional topics and material. The first ten chapters include the usual course in plane analytic geometry. Chapter 11 treats the geometric properties and constructions of conics. The second degree equation receives an extensive treatment in chapter 12. These two chapters unify the discussions given earlier. Chapters 13, 14, and 15 are on solid analytics. They introduce the student to the elementary methods used in analytic geometry of space and give certain concepts needed in the study of the calculus.

Answers to the odd-numbered exercises are listed in the back of the book. An answer book with answers to the even-numbered exercises may be had upon request.

FOREST MONTGOMERY
Lyons Township High School and Junior College
La Grange, Illinois

MATHEMATICAL BIBLIOGRAPHY

A list of some books that will be found useful for the enrichment of mathematics

This list of books makes no claim to completeness, and the books that are included or omitted have been weighed only in the scales of personal judgment or unreasoned choice.

DICTIONARY

James, Glenn, and James, Robert C. *Mathematics Dictionary*, Revised edition. Van Nuys, Calif.: The Digest Press 1943. 273 pp.
A volume of definitions, descriptions, facts, and formulas from all branches of mathematics.

HISTORY OF MATHEMATICS

Archibald, Raymond Clare. *Outline of the History of Mathematics*, 5th edition, revised and enlarged. The Mathematical Association of America, Inc., 1941. 76 pp.
A concise presentation in pamphlet form of historical information related to mathematics through the 19th century. Extensive list of references.

Ball, W. W. R.: *A Short Account of the History of Mathematics*, 5th edition. New York: The Macmillan Co., 1912. 520 pp.
A good elementary history by a well-known English writer.

Bell, Eric T. *The Development of Mathematics*, 2d edition. New York: McGraw-Hill Book Co., Inc., 1945. 367 pp.
A full treatment of the development of the larger movements and general concepts of mathematics from very early times to the present; shows how isolated discoveries and individual contributions are related to the total picture.

———. *Men of Mathematics*. New York: Simon and Schuster, Inc., 1937. 592 pp.
Biographies of thirty-five famous mathematicians in dramatic story form.

Cajori, Florian. *A History of Mathematics*, 2d edition, revised and enlarged. New York: The Macmillan Co., 1919. 516 pp.
A volume crammed with many names of persons who have contributed to the growth of mathematics.

Karpinski, Louis Charles. *The History of Arithmetic*. Chicago: Rand McNally and Co., 1925. 200 pp.
A full and authoritative history of arithmetic showing how people of many lands and times have done the operations of arithmetic, and the nature of the problems they have solved. Well illustrated.

Sanford, Vera. *A Short History of Mathematics*. Boston: Houghton Mifflin Co., 1930. 402 pp.
A short history of elementary mathematics (through calculus). Especially suitable for use of high school students.

Smith, David Eugene. *History of Mathematics*, 2 vol. Boston: Ginn and Co., 1923, 1925. 596 pp., 725 pp.
The most complete and authoritative history of mathematics written by an American. Generously illustrated.

———. *A Source Book in Mathematics*. New York: McGraw-Hill Book Co., Inc., 1929. 701 pp.

For one who wants to read epoch-making mathematical literature in the language of the masters who contributed the new concepts.

Yates, Robert C. *The Trisection Problem.* West Point, N. Y.: The author, 1942, 1947. 68 pp.

A complete, scholarly treatment of this historical problem. Shows many ways by which the problem has been solved.

Of General Mathematical Interest

Anderson, Raymond W. *Romping Through Mathematics.* New York: Alfred A. Knopf, Inc., 1947. 152 pp.

In the language of the man in the street, the author appeals to the intuition of intelligent laymen in clarifying certain mathematical ideas.

Bakst, Aaron. *Mathematics; Its Magic and Mastery.* New York: D. Van Nostrand Co., Inc., 1941. 790 pp.

This book contains many fascinating mathematical curios which are explained in nontechnical language. Many odd number relations are given.

Bell, Eric. T. *The Magic of Numbers.* New York: McGraw-Hill Book Co., Inc., 1946. 418 pp.

Shows how men of all ages have interwoven scientific number concepts with pseudo science and magic. Good biographies of a few ancient mathematicians.

———. *The Queen of the Sciences.* Baltimore: The Williams and Wilkins Co., 1931. 138 pp.

This book will make you proud of your interest in and knowledge of mathematics.

———. *Handmaiden of the Sciences.* Baltimore: The Williams and Wilkins Co., 1937. 216 pp.

Shows mathematics as the servant ready at the need of every science.

Courant, Richard, and Robert, H. E. *What Is Mathematics?* New York: Oxford University Press, 1941. 521 pp.

This book presupposes only the knowledge gained from a good high school mathematics course, but it explores some of the historical and maturer aspects of elementary mathematics. Good source of material for mathematics clubs.

Dantzig, Tobias. *Number: The Language of Science,* 3d edition, revised and enlarged. New York: The Macmillan Co., 1939. 320 pp.

"A critical survey written for the cultured non-mathematician."

Hogben, Lancelot. *Mathematics for the Million.* New York: W. W. Norton and Co., Inc., 1937. 647 pp.

This book brings mathematics down to a plane that all can appreciate and discusses it in a language which any intelligent layman can understand.

Kasner, Edward, and Newman, James. *Mathematics and the Imagination.* New York: Simon and Schuster, Inc., 1940. 380 pp.

One of the best of the books combining mathematical learning and amusement. Easy to read.

Lieber, Lillian R. *The Education of T. C. Mits,* revised and enlarged. New York: W. W. Norton and Co., Inc., 1944. 230 pp.

T. C. Mits is the-common-man-in-the-street, and his education is some painless and very interesting mathematics.

Sawyer, W. W. *Mathematician's Delight.* New York: Penquin Books, Inc., 1946. 215 pp.

An inexpensive book presenting an entertaining discussion of elementary mathematics.

Somervell, Edith L. *Rhythmic Approach to Mathematics.* Sold by Miss L. E. Christman, 1217 Elmdale Ave., Chicago. 1906. 32 pp.

Here is some attractive mathematics that can be done by a child with needle and thread.

Steinhaus, Hugo. *Mathematical Snapshots.* New York: G. E. Stechert and Co., 1938. 135 pp.

Without any attempt at organization, Steinhaus has written about some phases of mathematics that fascinate him and will fascinate you. Most of the things he describes can be made and handled.

Thompson, D'Arcy. *On Growth and Forum.* New York: The Macmillan Co., 1945. 1097 pp.

A biologist describes many natural forms and explains their development in mathematical language.

White, William F. *A Scrapbook of Elementary Mathematics.* La Salle, Ill.: The Open Court Publishing Co., 1927. 240 pp.

An accumulation of mathematical ideas and facts that one teacher found interesting and useful in his work.

Yates, Robert C. *Curves.* Ann Arbor, Mich.: J. W. Edwards, 1947. 245 pp.

An interesting treatment of the mathematical and mechanical properties of many curves.

Recreations and Amusements

Ball, W. W. R. *Mathematical Recreations and Essays* (11th edition) revised by H. S. M. Coxeter. New York: The Macmillan Co., 1942. 418 pp.

This revision is a great improvement over the original of an old favorite. All discussions are mathematically sound.

Dudeney, H. E. *Amusements in Mathematics.* New York: Thomas Nelson and Sons, 1917, 258 pp.

Interesting games and mathematical puzzles, problems and amusements which appeal to the amateur. Solutions are given for all problems.

Freeman, Mae and Ira. *Fun with Figures.* New York: Random House. 60 pp.

Simple mathematical experiences which young persons can have which will show the subject in a fascinating light.

Jones, Samuel I. *Mathematical Nuts for Lovers of Mathematics,* revised edition. Nashville, Tenn.: The author, 1936. 340 pp.

A collection of puzzle problems related to mathematics from arithmetic through trigonometry. Solutions are given for all problems.

———. *Mathematical Wrinkles; A Handbook for Teachers and Private Learners,* 4th edition, revised and enlarged. Nashville: The author, 1929, 361 pp.

Very similar to *Mathematical Nuts.*

Kraitchik, Maurice. *Mathematical Recreations.* New York: W. W. Norton and Co., Inc., 1942. 328 pp.

Somewhat more scholarly than a number of other books in this classification. The treatment of magic squares is particularly interesting.

Licks, H. E. *Recreations in Mathematics.* New York: D. Van Nostrand Co., Inc., 1917. 155 pp.

A carefully selected series of comments and sidelights that the teacher will find helpful as well as interesting.

Loomis, Elisha. *The Pythagorean Proposition,* 2d edition. Ann Arbor, Mich.: Edwards Brothers, Inc., 1940. 284 pp.

256 proofs of the Pythagorean theorem proposition. In every geometry class there will be some pupil who will have great interest in this collection. It will stimulate him to attempt contributions of his own.

Mott-Smith, Geoffrey, *Mathematical Puzzles for Beginners and Enthusiasts.* Philadelphia: The Blakiston Company, 1946. 248 pp.

Many of the old stand-by mathematical puzzles and some new ones not to be found in other books.

Northrop, Eugene P. *Riddles in Mathematics; A Book of Paradoxes.* New York: D. Van Nostrand Co., Inc., 1944. 262 pp.

An exceptionally fascinating book of paradoxes. The mathematical discussions are informative as well as interesting.

Row, T. Sundara (Sundara Rao, T.). *Geometric Exercises in Paper Folding,* edited by Beman and Smith. La Salle, Ill.: The Open Court Publishing Co., 1901. 148 pp.

A great many of the constructions of plane geometry can be done by simple folding of paper. This little book shows how many of these constructions can be done. It will be found of great assistance in preparation of material for mathematics exhibits.

Some Advanced Topics

Cell, John W. *Engineering Problems Illustrating Mathematics.* New York: McGraw-Hill Book Co., Inc., 1943. 172 pp.
Here is an excellent source of problems that make real and necessary use of mathematics.

Hardesty, Shortridge, and Wessman. *Preliminary Design of Suspension Bridges,* in Proceedings of American Society of Civil Engineers, 1938. 29 pp.
Shows how the bridge engineer uses mathematics as a necessary tool. Mathematics controls the form of the bridge.

Lieber, Lillian R. *Einstein Theory of Relativity.* New York: Farrar and Rinehart, Inc., 1945. 324 pp.
A lucid and accurate treatment of a difficult subject in the simplest possible language.

Miller, John A., and Lilly, Scott B. *Analytic Mechanics,* Revised edition, Boston: D. C. Heath and Co., 1935. 309 pp.
Mathematics is put to work to establish the laws on which the universe operates.

Thompson, James E. *Calculus for the Practical Man.* New York: D. Van Nostrand Co., Inc., 1931. 323 pp.
Calculus is employed to find the answers to some fascinating scientific problems.

Wilson, W. A., and Tracey, J. I. *Analytic Geometry,* Alternate edition. Boston: D. C. Heath and Co., 1937. 296 pp.
Lists of applications of various curves.

Wolfe, Harold E. *Introduction to Non-Euclidean Geometry.* New York: The Dryden Press, Inc., 1945. 247 pp.
When Euclid's fifth postulate is abandoned and others are substituted, what happens to our geometry? Is one geometry more true than another?

BAD TEMPER MORE LIKELY CAUSE FOR ACCIDENTS THAN LOW INTELLIGENCE

Almost all of us are intelligent enough to drive a car safely.

Impatience, bad temper and a show-off attitude cause more accidents than stupidity, declares Dr. Walter C. Bingham, Washington psychologist and consultant to the Director of Personnel of the Army General Staff.

If you get provoked when the other fellow eases in ahead of you, jumps the light, toots his horn unreasonably or mopes along, straddling both lanes when the light at the next corner is going to turn red in half a minute, you are letting yourself in for trouble.

A calm and reasonable attitude, even in the face of unrestrained back-seat driving, is called for if you want to be a safe driver.

Although there were about 30,000 fatal automobile accidents in the last year, the accident rate is decreasing. In the last 18 years the accident rate has been reduced by nearly half. This is in spite of the fact that there is much more driving now. There are many more automobiles on the roads and more miles of use per car.

One of the reasons for the decrease in accidents is the change of the green traffic lights at street intersections to a bluish green. This is an aid to color-blind people who cannot distinguish red from green when the green is pure but can often tell red from a bluish green.